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## CONTENTS OF PREVIOUS NUMBER

### SEPTEMBER 1944. NUMBER 3


Traumatism of the Frontal Sinuses., Ralph A. Fenton, M.D., Portland, Ore.

Vertical Nystagmus Produced by Peripheral Labyrinthine Lesions. E. A. Spiegel, M.D., Philadelphia, and N. P. Scala, M.D., Washington, D. C.

Pseudomembranous Angina Followed by Partial Pharyngeal Paralysis. Captain Joseph V. M. Ross, Medical Corps, Army of the United States.

Management of the Alveolar Fistula. Frederick T. Hill, M.D., D.Sc., Waterville, Maine.

An Otolaryngologic Aspect of Frontal Meningocele: Report of Cases. Major E. A. Stuart, Royal Canadian Army Medical Corps, Ca., Montreal, Canada.

Primary Tumors of Stensen's and Wharton's Ducts. Frederick A. Figi, M.D., and Willard D. Rowland, M.D., Rochester, Minn.

The Preepiglottic Space: Its Relation to Carcinoma of the Epiglottis. Louis H. Clerf, M.D., Philadelphia.

Ossifying Fibroma of the Superior Maxilla. H. James Hara, M.D., Ph.D., D.Sc. (Med.), Hinsdale, Ill.

Hemangioma of the Adult and of the Infant Larynx: A Review of the Literature and a Report of Two Cases. George B. Ferguson, M.D., Durham, N. C.

Prevention of Secondary Post-Tonsillectomy Hemorrhage with Sulfathiazole Gum. Francis Henry McGovern, M.D., Danville, Va.

Surgical Treatment of Nasal Obstruction: Indications for a Plastic Approach to Septal Deformity; Details of Plastic Procedures. Nathan A. Bolotow, M.D., Providence, R. I.

Case Reports:

Rhinosporidiosis. Major William H. Seale, Captain Clifton B. Flinn and Captain Edward C. Britt, Medical Corps, Army of the United States.

Meningitis Due to Post-Traumatic Cerebrospinal Rhinorrhea. Milo C. Schroeder, M.D., Loma Linda, Calif.

Clinical Notes; New Instruments and Technics:

A New Nasopharyngeal Radium Applicator. M. William Clift, M.D., Flint, Mich.

Progress in Otolaryngology. Summaries of the Bibliographic Material Available in the Field of Otolaryngology:

Peroral Endoscopy. Louis H. Clerf, M.D., and J. Robert Fox, M.D., Philadelphia, and Lieutenant Commander Stephen J. Ryan (MC), U.S.N.

Abstracts from Current Literature.

Society Proceedings:

College of Physicians of Philadelphia, Section on Otolaryngology, and Philadelphia Laryngological Society.

Directory of Otolaryngologic Societies.

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# DEVELOPMENT OF THE ORGAN OF CORTI IN RELATION TO THE INCEPTION OF HEARING

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The membranous labyrinth of the opossum Didelphis virginiana is still in a relatively early stage of development at birth and is entirely nonfunctional. This opossum is born thirteen days after fertilization and completes its development in the brood pouch of the mother. At the time it is born most of its organs are very embryonic, but by fifty days post partum it has reached a stage of development approximating that of most newborn mammals (McCrady [1]). The opossum in the pouch, therefore, provides embryonic material easy of access for experimental purposes.

Langworthy [2] noted the earliest sign of vestibular response in pouch young at 41 days, while Larsell, McCrady and Zimmermann [3] reported such responses at about 43 days. Acoustic function does not appear until about a week later. Larsell and McCrady [4] and Larsell, McCrady and Zimmermann reported acoustic responses in the form of a spasmodic contraction of trunk musculature in pouch young at 50 days. This was elicited by shrill, sharp whistling and by sharp clapping of the hands. The first strong response to a note of a known rate of vibration (E″, 1305 cycles per second) was obtained at 51 days, with slight response to notes of 1536 and 1024 cycles per second. Responses to the last-named notes increased in the 52 day pouch young. At 53 days middle C (256 cycles per second) evoked a trunk reflex. At 55 days this note brought forth a pinna reflex in addition to the trunk response, and on subsequent days pinna or tail reflexes, in addition to trunk movements, were usually observed in response to each of the notes used in the tests. The volume of sound was not measured in these earlier experiments, but it was noted that the small volume produced by a C″ tuning fork (1024 cycles per second) did not produce responses in pouch young of any of the ages tested, while the same note on the organette, producing much greater volume, elicited responses beginning at 51 days.

Following these observations, McCrady, Wever and Bray,[5] using a pure tone apparatus, made reflex tests on pouch young of the Mexican opossum (Didelphis marsupialis) ranging in age from 59 to 82 days. They obtained responses in a range of 1,000 to 4,500 cycles per second at the 59 day stage, 800 to 6,000 cycles at 66 days and 100 to 19,000 cycles at 80 days and older, with responses in a range of 300 to 14,000 cycles in 1 adult tested.

Measurement with the cathode ray oscillograph showed a much greater range of response. The method consisted of placing the active electrode of the apparatus in contact with the membrane of the round window, which can be exposed by a simple operation in the pouch young, and the indifferent electrode under the skin of the incision. The animal was secured in position so that the auditory meatus was 1 inch (2.5 cm.) from the end of the tube lead-

Read at the meeting of the American Academy of Ophthalmology and Otolaryngology, in Chicago, Oct. 14, 1943.

From the University of Oregon Medical School (Drs. O. Larsell and John F. Larsell) and the University of the South (Dr. McCrady).

The American Academy of Ophthalmology and Otolaryngology made possible the completion of this research by a grant from the research committee of its council.

1. McCrady, E., Jr.: The Embryology of the Opossum, American Anatomical Memoir 16, Philadelphia, Wistar Institute of Anatomy and Biology, 1938.

2. Langworthy, O. R.: The Behavior of Pouch Young Opossums Correlated with the Myelinization of Tracts in the Nervous System, J. Comp. Neurol. **46**: 201-248, 1928.

3. Larsell, O.; McCrady, E., Jr., and Zimmermann, A. A.: Morphological and Functional Development of the Membranous Labyrinth in the Opposum, J. Comp. Neurol. **63**:95-118, 1935.

4. Larsell, O., and McCrady, E., Jr.: Acoustic Function in Pouch Young of the Opossum, Proc. Soc. Exper. Biol. & Med. **32**:774-776, 1935.

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ing from a loudspeaker which relayed tones of desired pitch and intensity. The electrical effects produced in the cochlea were led from the active electrode through an amplifier to the oscillograph. The range of frequencies producing responses by this method was about 500 to 6,000 cycles per second at 59 days, 300 to 10,000 at 61 days, and 200 to 20,000 at 68 days, indicating a trend toward both lower and higher frequency responses with progressive development. In 1940 McCrady, Wever and Bray [6] reported another series of tests made by the electrical method on a litter of 8 pouch young of the Virginia opossum, ranging in age from 48 to 77 days when tested. Measurements were made on both ears in 6 and on 1 ear only in the remaining 2, the tonal range as well as the intensity of sound required being recorded. The results are indicated in the form of graphs in the paper cited. For convenience of reference in the present report they are represented in the accompanying table.

*Tones and Intensities Giving a Standard Response of 1 Microvolt in Cochleas of Opossums of Different Ages*

| Age of Animal, Days | Cochlea | Intensity in Decibels of Given Test Tone in Double Cycles per Second | | | | | | | | | Highest Tone Eliciting Response, Double Cycles per Second |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 200 | 300 | 500 | 700 | 1000 | 2000 | 3000 | 5000 | 7000 | 10000 | |
| 48 | Right | .. | .. | .. | .. | 47 | 38 | 41 | 41.5 | 45 | .. | 7000 |
| 51 | Left | .. | .. | .. | .. | 46.5 | 45 | 41 | 41.5 | .. | .. | 5000 |
| | Right | .. | .. | .. | .. | 40 | 43 | 36 | 34 | .. | .. | 7000 |
| 54 | Left | .. | .. | 32.5 | 31 | 30 | 27 | 29.5 | 33 | 39 | .. | 7000 |
| | Right | 24 | 30 | 30 | 24 | 17 | 24.5 | 38 | 31 | 29 | 35 | 14000 |
| 57 | Left | 23 | 30.5 | 19.5 | 18 | 20.5 | 27 | 16 | 32 | 31 | 33 | 12000 |
| 60 | Left | 17 | 20 | 32 | 26 | 16 | 29 | 10 | 23 | 21 | 32 | 16000 |
| | Right | 20 | 21.5 | 17 | 9 | 19 | 14 | 18 | 25 | 19 | 19 | 16000 |
| 63 | Left | .. | 24 | 25 | 17 | −2 | −0.5 | 5 | 5 | 1 | 3 | 16000 |
| | Right | .. | 17.5 | 16.5 | 14 | 8 | 1 | −1 | 3 | −8 | −1 | 16000 |
| 70 | Left | .. | 29 | 24 | 22 | 18 | 6 | 13 | 20.5 | 9 | 9 | 14000 |
| | Right | 17 | 12 | 12 | 12 | 11 | −3.5 | 9 | 14 | 15 | 23.5 | 12000 |
| 77 | Left | .. | 21.5 | 17 | 13 | 8 | −5 | −10 | −20 | −23 | −20 | 19000 |
| | Right | .. | 14 | 12 | 10 | 3 | −8 | −8 | −22 | −26 | −23 | 26000 |

In the first experimental studies reported by Larsell, McCrady and Zimmermann,[8] in 1935, the cochleas were studied histologically only in a preliminary way. It was pointed out that the cochlea has acquired approximately the two and one-fourth turns characteristic of the adult 16 days after birth. Hair cells and nerve fibers are present as early as the 29 day stage and probably earlier, and the tunnel is present as a narrow cleft in the middle coil and in the distal part of the basal coil at this stage.

The 48 to 77 day pouch young tested by McCrady, Wever and Bray were prepared for histologic study after fixation of the heads with the cochleas in situ. The temporal bone was sectioned, and the sections were mounted serially and stained with hematoxylin and eosin. These series were supplemented by untested cochleas from pouch young of corresponding stages, obtained from the Wistar Institute and stained by the Bodian method to bring out nerve fibers and other details of structure. The Bodian series form the basis of most of the figures in the present report. It would be preferable to have figures and descriptions all based on tested specimens, but comparison of the cochleas of the tested animals with those of the untested series of corresponding ages shows so considerable a degree of uniformity in the differentiation at corresponding stages that the use of histologic pictures from the untested animals appears to be justified because of the greater detail provided by the special technic employed.

For brevity and for facility in comparing the different stages the description of the cochlea in which hearing has been established will be based on sections of the 51 day opossum and will be followed by an account of corresponding parts at younger and older stages. Wada [7] has given detailed measurements of the parts of the cochlea of the rat at various stages of growth, and Hensen,[8] Böttcher,[9] Retzius,[10] Held [11] and

6. McCrady, E., Jr.; Wever, E. G., and Bray, C. W.: A Further Investigation of the Development of Hearing in the Opposum, J. Comp. Psychol. **30**:17-21, 1940.

7. Wada, T.: Anatomical and Physiological Studies of the Growth of the Inner Ear of the Albino Rat, American Anatomical Memoir 10, Philadelphia, Wistar Institute of Anatomy and Biology, 1923.

8. Hensen, V.: Zur Morphologie der Schnecke des Menschen und der Säugetiere, Ztschr. f. wissensch. Zool. **13**:481, 1863; abstracted, Schmidt's Jahrb. **122**:168-171, 1864.

9. Böttcher, A.: Ueber Entwickelung und Bau des Gehörlabyrinthes nach Untersuchungen an Säugethieren, Dresden, E. Blockmann u. Sohn, 1869.

10. Retzius, G.: Das Gehörorgan der Wirbelthiere, Stockholm, Samson & Wallin, 1884, vol. 2.

11. Held, H. H.: Die Cochlea der Säuger und der Vögel, ihre Entwicklung und ihr Bau, in Bethe, A.; von Bergmann, G.; Embden, G., and Ellinger, A.: Handbuch der normalen und pathologischen Physiologie, Berlin, Julius Springer, 1926, vol. 11, pp. 467-543.

others have recorded similar measurements for embryos or adults of other mammals. We have not undertaken such measurements in the opossum pouch young but instead have attempted to fill a gap by noting the degree of differentiation of the supporting apparatus of the organ of Corti and of the tunnel in the several turns of the cochlea at various stages and to correlate these observations with the range of hearing as measured by oscillographic methods. Attention has also been directed to the development of the hair cells, but the technic employed was not favorable for study of their finer structure, which might give some clue as to when they become functional. The tectorial membrane has been studied intensively in various animals by Hardesty,[12] Shambaugh [13] and others. In our preparations it is so shrunken and distorted by the method of fixation employed that only its extent in the cochlear coils will be indicated, but it is attached to the spiral organ in many of the sections. The basilar membrane does not show any obvious changes at the stages studied, save increase in length and breadth with the growth of the cochlea.

*Fifty-One Day Opossum.*—The left tested cochlea shows some differentiation of the organ of Corti at the beginning of the apical coil. The tunnel is recognizable as a narrow cleft to a level of about 25 sections 16 microns thick, i. e., 0.4 mm., from the apical tip of the cochlear duct. The middle coil and the upper part of the basal coil show differentiation of the organ of Corti, but the tunnel is poorly shown below the middle of the basal coil. The lower extremity of the cochlear duct rests on bone, the scala tympani continuing as a narrow cecum beneath a bony ridge. The right tested cochlea shows the organ of Corti differentiated as far as the beginning of the apical coil, with undifferentiated epithelium beyond this level to the tip of the cochlear duct.

Fig. 1.—Photomicrograph of a vertical section of the cochlea of a 51 day pouch young opposum; Bodian stain.

12. Hardesty, I.: On the Nature of the Tectorial Membrane and Its Probable Role in the Anatomy of Hearing, Am. J. Anat. **8**:109-179, 1908; On the Proportions, Development and Attachment of the Tectorial Membrane, ibid. **18**:1-72, 1915.

13. Shambaugh, G. E.: A Restudy of the Minute Anatomy of Structures in the Cochlea with Conclusions Bearing on the Solution of the Problem of Tone Perception, Am. J. Anat. **7**:245-257, 1907.

In Bodian sections of the cochlea of the 51 day opossum (fig. 1) the organ of Corti and the tectorial membrane are present in all the turns save the distal part of the apical coil. Here the epithelium is of the low columnar type, without differentiation (fig. 2 *A*). This picture is characteristic of the distal third of the apical coil at 51 days. At about the middle third of the apical coil at this stage the epithelium becomes taller and heaps up at the position of the basilar membrane later to be occupied by the tunnel and its surrounding cells. A few sections below this point, reading toward the middle coil, a slit appears with tall cells on each side (fig. 4 *AA*). These have a differentiation somewhat more advanced than that in the proximal zone of the apical coil in the 48 day opossum (fig. 8 *B*). The slit is the tunnel of Corti, and the tall epithelial cells represent an early stage in the differentiation of the pillars. It will be noted that the bases of the pillars are broad and that the distal ends of the cells taper and are elongated with a slight lateral bend. They end against the cuticular membrane, which is present as a thin birefringent layer over the entire organ of Corti in early stages of its development. In the more fully differentiated portions of the spiral organ in later stages the head processes appear to fuse with the cuticular membrane and, together with the phalangeal processes of the cells of Deiters, form the reticular plate (fig. 4 *G*). A few sections farther on in the 51 day pouch opossum (fig. 4 *A*) the bases of the pillars are greatly widened, and the phalangeal cells show a slight tapering toward the cuticular membrane. The hair cells are more differentiated. In the proximal part of the apical coil (fig. 2 *B*, right) the slit has becomes a narrow triangular space and the hair cells are still further differentiated. The phalangeal cells taper more sharply.

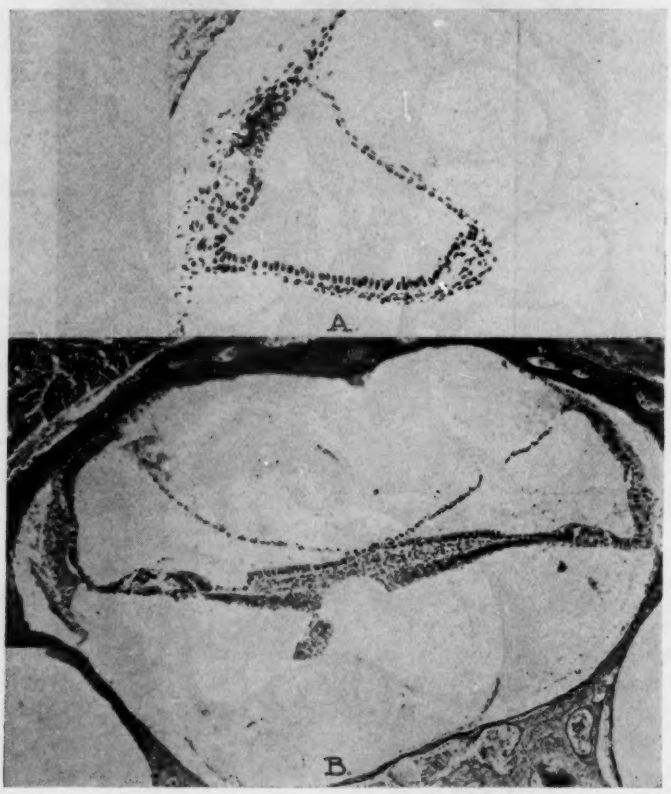


Fig. 2.—Photomicrographs of sections of the cochlear duct and organ of Corti of a 51 day opposum; Bodian stain: *A*, distal third of the apical coil. *B*, proximal part of the apical coil (right) and distal part of the middle coil (left).

A short distance proximal to this level, i. e., toward the base of the cochlea, the organ of Corti shows a widening of the tunnel, which here assumes a roughly quadrilateral outline, but with rounded corners (figs. 4 *A* and 10). The bases of the pillars are much broadened on the basilar membrane, and the distal parts of these cells are enlarged and begin to show convexity in the outer pillars and concavity in the inner pillars. Some of the phalangeal cells show a division (fig. 4 *A*) under the cuticular membrane, the beginning of the phalanges of the reticular plate. Still farther,

reading toward the base, the middle coil (figs. 4 *B* and 10) has a relatively large tunnel of Corti, roughly triangular in transverse sections. The pillars are tall, and their heads are more differentiated, that of the inner pillar being elongated into a thin, concave process under the cuticular membrane, while the outer pillar shows a terminal enlargement with convex upper surface which fits into the concavity of the opposite pillar in the manner of an articulation. The pillars show the

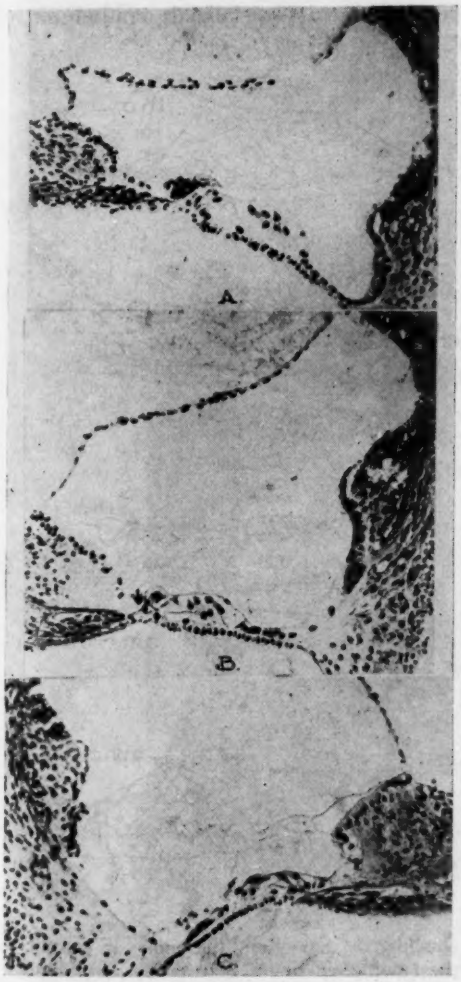


Fig. 3.—Photomicrographs of sections of the middle and basal coils of the cochlea of a 51 day opposum; Bodian stain: *A*, middle coil; *B*, distal part of basal coil; *C*, middle part of basal coil.

supporting hillocks and tonofibrils, which are beginning to appear at this level, and the heads show dark masses, the ellipsoid bodies, which apparently represent differentiating tonofibrils. Some of the phalangeal cells show the beginning of protoplasmic shoulders for support of the hair cells. In the distal part of the basal coil and the adjacent region of the middle coil (figs. 3 *A*, 4 *C* and 10) the pillars and the phalangeal cells approach the adult degree of differentiation. Farther downward in the basal coil (figs. 4 *D* and *E* and 10) the tunnel gradually becomes smaller and more rounded, and the pillars and supporting cells show less differentiation, with absence of the dark-staining ellipsoid bodies and of the supporting hillocks toward the proximal part of the basal coil. At about the middle of this coil the pillars begin to lose the marked concavoconvex pattern of their distal ends and assume a juvenile appearance similar to that in the proximal part of the apical coil. This is increasingly marked toward the proximal part of the basal coil (fig. 4 *E*), and the tunnel becomes a somewhat rounded space. The hair cells gradually are reduced in size. Nerve fibers are present in all the coils, but in the apical coil they do not extend beyond the zone of differentiation of hair cells.

*Forty-Eight Day Opposum.*—The middle part of the apical coil shows an early stage of differentiation of the organ of Corti. The tunnel is a mere slit (figs. 8 *B* and 10), and even this disappears apically. The tectorial membrane extends only to the first part of the apical coil. In the adult opossum this coil has but a quarter of a turn; at 48 days the turn is somewhat less. Toward the middle of the second coil the tunnel broadens and the pillars show early stages of differentiation. Reading toward the basal coil, the pillars appear more and more mature (figs. 8 *C, D* and *E* and 10). In the proximal part of the middle coil and the distal part of the basal coil, the tunnel appears quite well differentiated (figs. 8 *E* and 10), and the pillars show the tonofibrillar structures, which, however, are absent above and below this zone. Below this level there is a gradual narrowing of the tunnel. This feature is increasingly apparent as the base of the cochlea is approached, owing in part to the reduced width of the basilar membrane but largely to an early stage of differentiation. In the middle zone of the basal coil the tunnel and pillars assume a juvenile appearance (fig. 8 *F*), and the tunnel becomes smaller and more slitlike the nearer the cochlear base is approached (figs. 8 *G* and *H* and 10). Comparison of the pillars as shown in figures 8 *C* (48 days) and 4 *B* (51 days), from approximately the same level of the cochlea, shows that these structures in the middle coil at 48 days are much less developed, corresponding more nearly to the tunnel and the pillars in the transition to the apical coil of the 51 day opossum (fig. 4 *A*) save that the pillars are more differentiated in the latter.

The middle third of the middle coil at 48 days (figs. 8 *D* and 10) shows a differentiation of

pillars corresponding approximately to the distal third of the middle coil at 51 days (figs. 4 *B* and 10), but the tunnel is much smaller in the 48 day pouch young and the heads of the pillars are less differentiated. The region of transition of the middle coil into the basal coil is well differentiated both as to pillars and tunnel, resembling the condition in the corresponding level at 51 days (compare figs. 4 *C*, 8 *E* and 10), but the heads of the pillars appear less developed in the younger opossum. The hair cells are well differentiated in the upper third of the basal coil and in the middle coil but are small and juvenile in intimation of curving and differentiation. The distal part of the middle coil (figs. 9 *B* and 10) has a broad tunnel and an articulation-like arrangement of the pillars. Early differentiation of the organ of Corti extends to within about 0.2 mm. of the apical end of the cochlear duct (fig. 5 *B*, right), where a narrow slit apparently represents the first indication of the tunnel. No differentiated pillars or hair cells and no tectorial membrane are present in this region. The remaining distal part of the apical coil shows no differentiation of specialized epithelium (fig. 5 *A*).

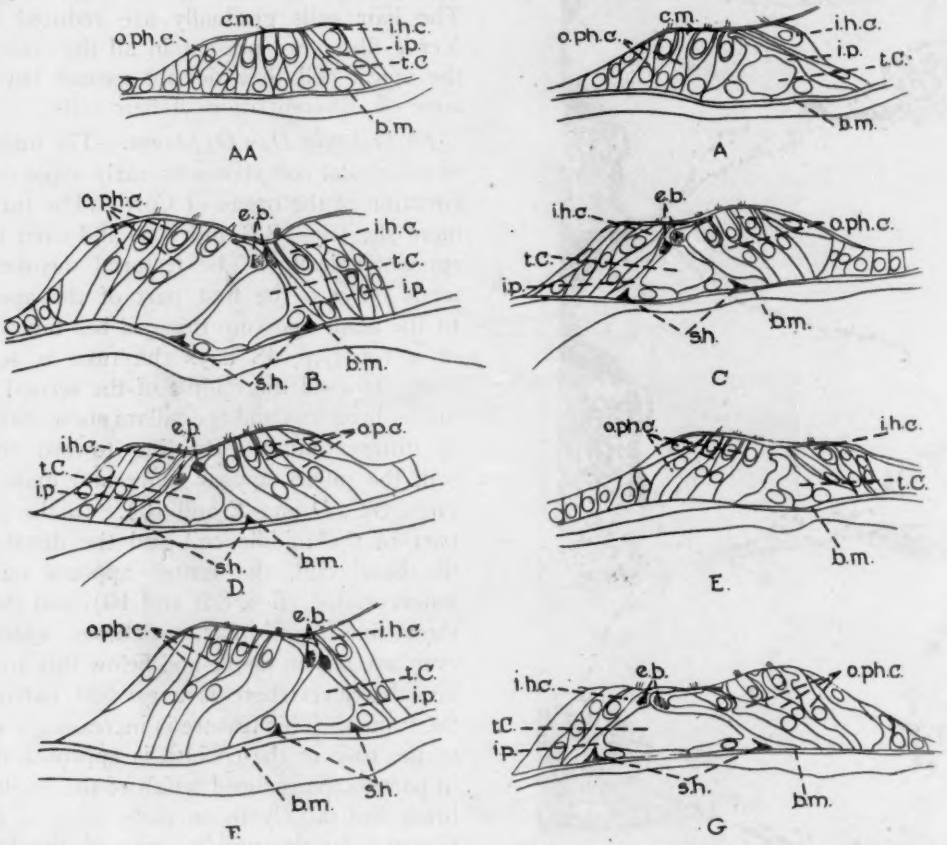


Fig. 4.—Organ of Corti of 51, 48 and 60 day opossums, showing the tunnel and the pillars in greater detail; Bodian stain; camera lucida; × 320: *AA*, apical coil, the farthest point reached by nerve fibers at 51 days. *A*, transition zone from the middle to the apical coil at 51 days, about level 4 *A* of figure 10. *B*, distal part of the middle coil at 51 days, about level 4 *B* of figure 10. *C*, distal part of the basal coil at 51 days, about level 4 *C* of figure 10. *D*, upper part of the middle third of the basal coil at 51 days, about level 4 *D* of figure 10. *E*, lower third of the basal coil at 51 days, about level 4 *E* of figure 10. *F*, middle third of the middle coil at 48 days. *G*, lower part of the apical coil at 60 days. The abbreviations are explained as follows: *b.m.*, basilar membrane; *c.m.*, cuticular membrane; *i.h.c.*, inner hair cell; *i.p.*, inner pillar; *o.ph.c.* (or *o.p.c.*), outer phalangeal cell; *t.C.*, tunnel of Corti; *e.b.*, ellipsoid bodies; *s.h.*, supporting hillock.

the first part of the apical coil and below the middle zone of the basal coil.

*Fifty-Four Day Opossum.*—The middle zone of the apical coil (figs. 9 *A* and 10) shows a fairly wide triangular tunnel. The bases of the pillars have the characteristic feet on the basilar membrane, but the distal ends show only the first

The middle coil at this stage is well differentiated throughout (figs. 5 *B*, left, and 6 *A*), and the distal third of the basal coil has a well developed organ of Corti (fig. 6 *B*). The middle zone of this coil shows more differentiation than the earlier stages, as does also its proximal part, but there is less differentiation of pillars and

phalangeal cells and there is a smaller and more slitlike tunnel the nearer the base of the cochlea is approached (figs. 6 *C* and 9 *D*). Hair cells are well developed throughout, as shown in figure 6, save in the distal apical and the most proximal part of the basal coil.

*Fifty-Seven Day Opossum.*—At this stage the proximal part of the apical coil is well differentiated, and the organ of Corti, apparently functional, extends to within 128 microns from the apical end of the cochlear duct. The middle coil is well differentiated throughout, and in the basal coil good differentiation extends to about the middle portion, with progressively less development below this level, so far as could be judged from torn sections. In the right cochlea of the same animal, not tested, the apparently functional organ of Corti extends to the lower part of the middle third of the basal coil.

*Sixty Day Opossum.*—The apical coils in both cochleas show differentiation of the organ of Corti proximally, with a low tunnel, broad at its base. The distal part of this coil shows a heaping up of epithelium but only a slitlike tunnel. The last section, apically, in which the organ can be recognized is 160 microns from the tip of the cochlear duct. The tunnel and the tectorial membrane appear in the next section downward, and a few sections farther toward the base well defined pillars and a broadening of the tunnel are apparent.

The tunnel and pillars are well differentiated in the distal part of the basal coil and in the middle coil (fig. 7 *A*, left), in which region the organ of Corti is most mature. The degree of differentiation of pillars and tunnel at about the middle of the basal coil is shown in figure 9 *E*. The tunnel continues as a relatively broad space well toward the oval window, but the pillars are more juvenile in appearance in the proximal zone (fig. 9 *F*). The organ of Corti shows only early stages of differentiation in the proximal third of the basal coil. The tunnel becomes smaller toward the base, as seen by comparison of figures 9 *F* and 7 *C*. The hair cells cannot be distinguished from other cells in the lower part of the

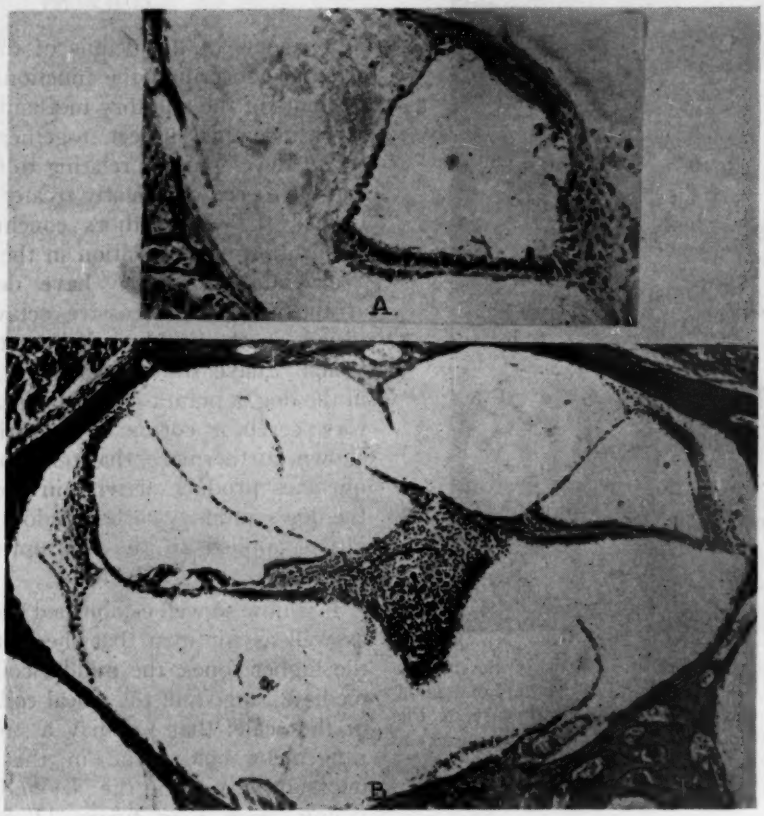


Fig. 5.—Photomicrographs of sections of the apical coil of the cochlea of a 54 day opossum; Bodian stain: *A*, distal part of the apical coil, near the tip, showing undifferentiated epithelium. *B*, right, distal part of the apical coil, proximal to *A*, showing early differentiation of the epithelium of the organ of Corti and a narrow slit representing the tunnel at this level. Left, distal part of the middle coil.

basal coil, but the pillars, while small, are distinguishable. However, they are not differentiated into the articulation characteristic of their distal ends in the more mature regions of the cochlea. The most proximal part of the coil rests on bone, and the scala tympani ends as a small diverticulum beneath a bony shelf.

*Sixty-Three Day Opossum.*—The organ of Corti is well differentiated in the proximal part of the apical coil on the right side, but how far

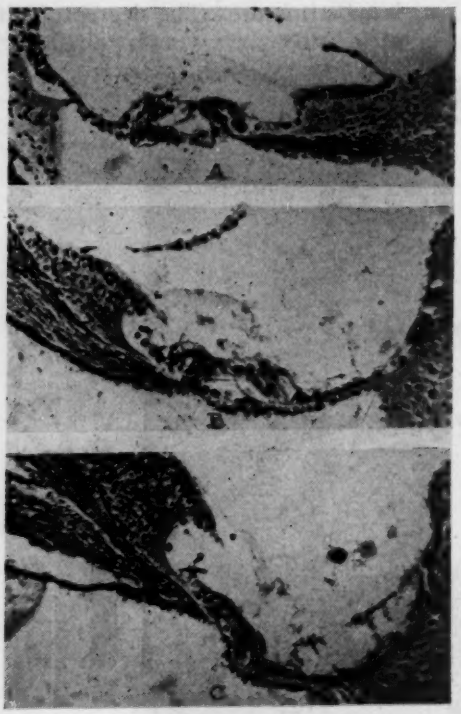

Fig. 6.—Photomicrographs of sections of the middle and basal coils of the cochlea of a 54 day opossum: Bodian stain: *A*, middle coil; *B*, distal part of the basal coil; *C*, proximal part of the basal coil.

toward the apex could not be determined because of torn sections. Also the distal and middle parts of the basal coil show good differentiation, but the proximal part is juvenile, with a narrow tunnel. Hair cells and pillars can be distinguished in Bodian sections, but the pillars are small and the hair cells are not greatly different from the neighboring supporting cells. The middle coil shows well advanced development of all its elements. The tunnel reaches the basal end of the cochlear duct as a triangular space (figs. 9 *G* and 10) but of small size owing to narrowing of the basilar membrane. The distal ends of the pillars in this region show the beginning of differentiation, as illustrated in the figure. The hair cells are small. The tonofibrillar structures are present both in the apical and in the basal coils.

*Seventy Day Opossum.*—At 77 days growth appears to be complete. The pillars are tall save at the tip of the apical coil, and the tunnel is differentiated in all the coils but has not yet extended to the tip of the apical coil. This may account for the fact that the lowest notes registered in the opossum tests were about 200 cycles per second, although Stevens, Davis and Lurie [14] and Culler [15] obtained responses in the guinea pig as low as 62 cycles per second. The shorter apical coil of the opossum may account for the limitation of range in the low tones.

## COMMENT

A review of the details of the evidence now at hand concerning the functions of the various elements of the auditory mechanism is not necessary since this subject, together with the more recent developments relating to theories of hearing, have been excellently treated by Stevens and Davis.[16] These authors conclude in favor of localization of stimulation in the organ of Corti. Walzl and Bordley [17] have demonstrated the arrangement of successive octaves at equal intervals in the cochlea of the cat. Woolsey and Walzl [18] have shown in the cat, and Tunturi [19] in the dog, a point to point projection to the auditory cerebral cortex. Tunturi's studies have shown, furthermore, that pure tones of given frequencies produce activity in the same zones of the dog's auditory cortex as does electrical stimulation applied to the appropriate part of the cochlea.

It is now so well established for several animals as well as for man that the basal coil mediates the higher tones, the middle coil those of intermediate range and the apical coil the lower tones of the scale, that we may assume that this arrangement holds true in the cochlea of the opossum also. In the 48 and 51 day pouch young, zone 1 in figure 11 had attained the

14. Stevens, S. S.; Davis, H., and Lurie, M. H.: The Localization of Pitch Perception on the Basilar Membrane, J. Gen. Psychol. **13**:297-315, 1935.

15. Culler, E. A.: Is There Localization in the Cochlea for Low Tones? Discussion from Point of View of Animal Experimentation, Ann. Otol., Rhin. & Laryng. **44**:807-813, 1935.

16. Stevens, S. S., and Davis, H.: Hearing, New York, John Wiley & Sons, Inc., 1938.

17. Walzl, E. M., and Bordley, J. E.: Effect of Small Lesions of Organ of Corti on Cochlear Potentials, Am. J. Physiol. **135**:351-360, 1942.

18. Woolsey, C. N., and Walzl, E. M.: Topical Projection of Nerve Fibers from Local Regions of Cochlea to Cerebral Cortex of Cat, Bull. Johns Hopkins Hosp. **71**:315-344, 1942.

19. Tunturi, A. R.: Audiofrequency Localization in the Acoustic Cortex of the Dog, Am. J. Physiol. **141**: 397-403, 1944.

highest degree of differentiation. At 48 days functional differentiation apparently extended apically to zone 2, and at 51 days to zone 3. In the basal coil functional differentiation at 51 days extended to zone 7 (fig. 11). The limits of response at 48 days, as shown in the accompanying table, were 1,000 and 7,000 cycles per second at 47 decibels. At 51 days they were 1,000 and 5,000 cycles at 46.5 decibels. The first response noted in the opossum, as already stated, was to about 1,300 cycles per second at 50 days. If the region of greatest differentiation at 48 and 51 days, namely zone 1 of figure 11, may be regarded as serving tones of about this range, we have a starting point for localization of other tones, those of lower pitch apically and higher tones toward the base of the cochlea. The region of reception for 1,000 cycles per second at 48 days may then be regarded as localized in zone 2 (fig. 11) and to have reached zone 3 at 51 days. This must mean either an apical extension of the region of receptivity for this tone or an apical migration of the locus of receptivity.

By 54 days zone 4 of figure 11 represents the apical limit of differentiation of the supporting apparatus to apparently functional stage. As shown in the table, the lower limit of response at this stage was 200 cycles per second in the right cochlea and 500 in the left, at 24 and 32.5 decibels respectively. At 60 days the apical limit of differentiation had reached zone 5, with response in both cochleas to 200 cycles per second at 17 decibels on the left side and at 20 decibels on the right. By 63 days differentiation had reached zone 6, with response to 300 cycles

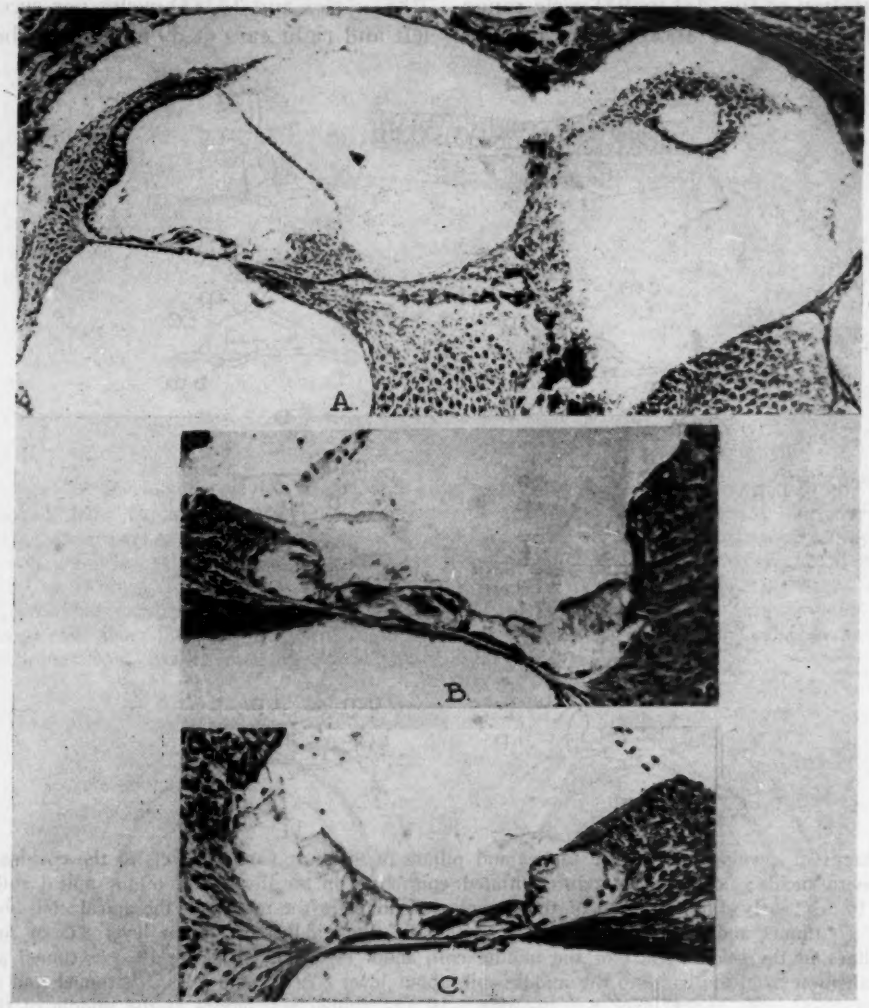


Fig. 7.—Photomicrographs of the cochlea of a 60 day opossum; Bodian stain: *A*, tip of the apical coil (right) and distal part of the middle coil (left); *B*, middle part of basal coil; *C*, proximal part of basal coil.

per second at 24 decibels and at 17.5 decibels on the left and right sides, respectively. Zone 6 is somewhat proximal to the region of the apical coil indicated by Stevens and Davis [16] (their fig. 140) as the locus of 250 cycles per second in man. Possibly further differentiation in the pouch young would advance it more apically, but our sections of stages subsequent to 60 days were not favorable for accurate determination of this point. The stages described indicate that along with apical differentiation of the supporting apparatus there is either an apical extension or an apical migration of the 200 to 300 cycle range comparable to that of the 1000 cycle range in most readily explainable by increased elaboration of the supporting structure in the apical direction.

Our sections of the greater part of the basal coil in the 48 day pouch young were not favorable for determining the lower limit of differentiation of the spiral organ, but an apparently functional stage of differentiation of the pillars and the tunnel had reached zone 7 of figure 11 at 51 days. The highest limit of response at this stage was 5000 cycles per second at 34 decibels, although at 48 days it was 7000 cycles at 45 decibels. In the 54 day pouch young the high limits were 7000 cycles and 14,000 cycles per second for the left and right ears at 39 and 29 decibels, respectively, and differentiation had reached zone 8 in the left cochlea. The 60 day pouch young responded to 16,000 cycles per second at 31.5 decibels, and differentiation of pillars and tunnel had reached zone 9. In subsequent stages, as already described, differentiation continued toward the base, and the 77 day pouch young responded to a maximum of 26,000 cycles per

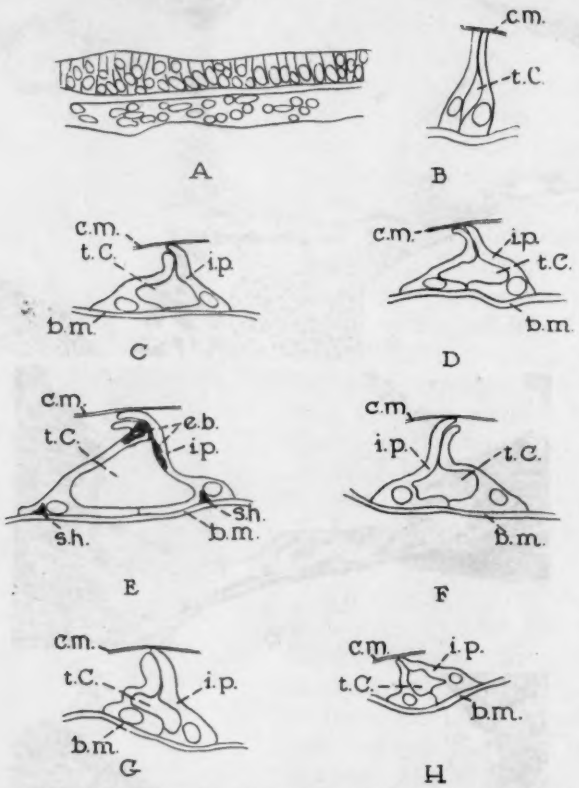


Fig. 8.—Stages of development of the tunnel and pillars of Corti at various levels of the cochlea of a 48 day opossum; Camera lucida; × 386: *A*, undifferentiated epithelium in the distal half of the apical coil, about level 8 *A* of figure 10. *B*, early differentiation of the tunnel and pillars in the middle of the apical coil, about level 8 *B* of figure 10. *C*, tunnel and pillars in the distal portion of the middle coil, about level 8 *C* of figure 10. *D*, tunnel and pillars in the middle third of the middle coil, about level 8 *D* of figure 10. *E*, tunnel and pillars in the zone of transition from the basal to the middle coil, about level 8 *E* of figure 10. *F*, tunnel and pillars in the upper third of basal coil, about level 8 *F* of figure 10. *G*, tunnel and pillars at the middle of the basal coil, about level 8 *G* of figure 10. *H*, tunnel and pillars near the base of the basal coil, about level 8 *H* of figure 10. The abbreviations are explained as follows: *c.m.*, cuticular membrane; *t.C.*, tunnel of Corti; *i.p.*, inner pillar; *b.m.*, basilar membrane; *e.b.*, ellipsoid bodies; *s.h.*, supporting hillock.

earlier stages. The evidence for localization of tonal ranges in adult animals (Culler [15]; Stevens and Davis [20]) favors the interpretation that migration rather than extension occurs. On the theory of tonal localization in the organ of Corti, such a migration of locus of receptivity appears

20. Stevens and Davis,[16] p. 370.

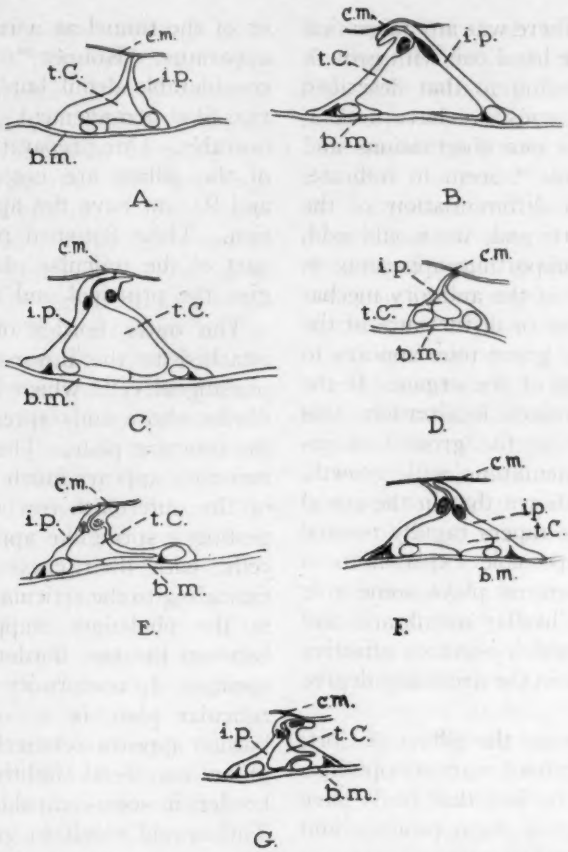


Fig. 9.—Stages of development of the tunnel and pillars of Corti in the 54, the 60 and the 63 day opossum; Camera lucida; × 386: *A*, approximately the middle of the apical coil, about level 9 *A* of figure 10, in the 54 day opossum. *B*, distal part of the middle coil, about level 9 *B* of figure 10, in the 54 day opossum. *C*, proximal part of the middle coil, about level 9 *C* of figure 10, in the 54 day opossum. *D*, proximal part of the basal coil, about level 9 *D* of figure 10, at 54 days. *E*, about the middle of the basal coil, about level 9 *E* of figure 10, in the 60 day opossum. *F*, proximal part of the basal coil, about level 9 *F* of figure 10, in the 60 day opossum. *G*, proximal part of the basal coil, about level 9 *G* of figure 10, at 63 days. The abbreviations are explained as follows: *c.m.*, cuticular membrane; *b.m.*, basilar membrane; *i.p.*, inner pillar; *t.C.*, tunnel of Corti.

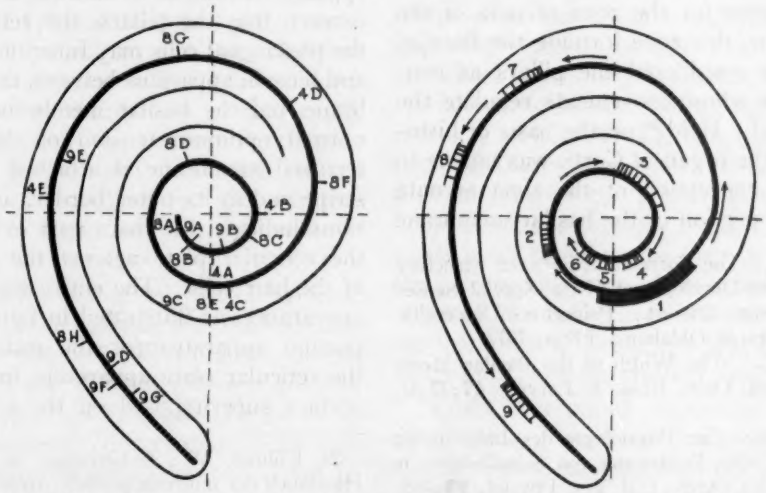


Fig. 10.—Diagram of the cochlea showing the approximate levels of the sections of the organ of Corti or of the tunnel and pillars illustrated in figures 4, 8 and 9. The numerals and letters indicate the approximate levels of the figures with corresponding designations.

Fig. 11.—Diagram of the cochlea to show the zones of apparently functional differentiation reached at various stages of development as described in the text. Zone 1 represents the region of greatest differentiation of the organ of Corti, confined to the distal part of the basal coil and the neighboring part of the middle coil, in the 48 day opossum. The arrows indicate the direction of subsequent differentiation.

second. Whether or not there was any migration of locus of response in the basal coil with growth of the cochlea, corresponding to that described in the middle and apical coils, we have no evidence. If we assume, as our observations and those of Wada [7] and Lane [21] seem to indicate, that a certain degree of differentiation of the tunnel and pillars of Corti and, we would add, the remainder of the supporting apparatus is necessary for functioning of the auditory mechanism in mammals, the zone of disturbance of the membrane necessary to a given tone appears to migrate with development of the organ. If the basilar membrane determines localization, this might be accounted for on the ground of increased breadth of the membrane with growth. However, Wever [22] has shown that in the apical coil the basilar membrane tapers rapidly toward its terminus. Another possible explanation is that the supporting apparatus plays some role in conjunction with the basilar membrane and other structures, a role which becomes effective only as these elements attain the necessary degree of differentiation.

Concerning the function of the pillars of Corti and, with them, of the tunnel, various opinions have been expressed. The fact that birds have no pillars although many of them produce and no doubt hear a considerable range of notes is the great stumbling block in the way of ascribing a function to these structures. Helmholtz, in his first enunciation of the resonance theory of hearing, postulated that the pillars are the resonators. He subsequently changed this view in favor of the fibers of the basilar membrane. Ewald [23] held that the pillars constitute a tension apparatus for the zona arcuata of the basilar membrane, this zone forming the floor of the tunnel. He considered the pillars as contractile elements whose movements regulate the size of the tunnel. Held,[24] on the basis of histologic studies of the organ of Corti, was unable to accept Ewald's conception of the zona arcuata as the vibrating portion of the basilar membrane or of the tunnel as a regulating accommodation apparatus. Kölmer [25] described the pillars in considerable detail but stated that the articulation-like arrangement of their heads is not movable. Our preparations show that the heads of the pillars are not fused together (figs. 8 and 9) but have the appearance of an articulation. Their flattened processes form the inner part of the reticular plate, to which the pillars give the principal and more rigid support.

The outer border of the reticular plate is attached to the inward bending row of outer phalangeal cells which have long curving tonofibrils whose ends spread out in the border of the reticular plate. The outer supporting structure thus appears much less rigid, the tonofibrils of the outermost row of phalangeal cells suggesting a springlike apparatus. The phalangeal cells, with their curved bundles of tonofibrils extending to the reticular plate and spreading out in the phalanges, support the reticular plate between the two borders as a series of minute springs. In conformity with this conception, the reticular plate is so supported that its inner border appears relatively immobile save as the pillars may bend slightly, while toward its outer border it seems capable of greater movement. This would result in gradations of elasticity in the reticular plate.

Retzius,[10] Shambaugh,[13] Prentiss,[26] Kishi [27] and others, from histologic studies, held that the tectorial membrane is attached to the spiral organ, while Shambaugh, Prentiss and others stated that the hairs of the receptor cells also attach to the tectorial membrane. It therefore appears reasonable to assume, if these views are correct, that the pillars, the reticular plate and the phalangeal cells may function as a cushioning and tension apparatus between the tectorial membrane and the basilar membrane to maintain a normal optimum tension of the cilia. If the tectorial membrane is attached along Hensen's stripe and at its outer border, as many observations indicate, the main part of it thus rests on the reticular plate against the projecting ends of the hair cells. The entire mechanism has the appearance, as illustrated in figure 12, of a supporting apparatus for the tectorial membrane, the reticular plate apparently forming an elastic surface superimposed on the basilar membrane

21. Lane, H. H.: The Correlation Between Structure and Function in the Development of the Special Senses of the White Rat, Dissert., Princeton University, Norman, University of Oklahoma Press, 1917.

22. Wever, E. G.: The Width of the Basilar Membrane in Man, Ann. Otol., Rhin. & Laryng. **47**:37-47, 1938.

23. Ewald, J. R.: Zur Physiologie des Labyrinths: VII. Mittheilung. Die Ergänzung von Schallbildern in der Camera acustica, Arch. f. d. ges. Physiol. **93**:485-500, 1903.

24. Held, H.: Untersuchungen über den feineren Bau des Ohrlabyrinthes der Wirbeltiere: II. Zur Entwicklungsgeschichte des Cortischen Organs und der Macula acustica bei Säugetieren und Vögeln, Abhandl. d. math.-phys. Kl. d. k. sächs. Gesellsch. d. Wissensch. **31**:193-293, 1909.

25. Kölmer, W.: Gehörorgan, in Möllendorff, W.: Handbuch der mikroskopischen Anatomie des Menschen, Berlin, Julius Springer, 1929.

26. Prentiss, C. W.: On the Development of the Membrana Tectoria with Reference to Its Structure and Attachments, Am. J. Anat. **14**:425-460, 1913.

27. Kishi, K.: Corti'sche Membran und Tonempfindungstheorie, Arch. f. d. ges. Physiol. **116**:112-123, 1907.

and presumably modifying and refining such elasticity as the latter may possess.

Both the basilar membrane and the tectorial membrane are present in all vertebrates beginning with the anurans, that is in all types receiving sound waves from the air, but only mammals have the organ of Corti. Both membranes, therefore, must have basic functions in connection with sound reception. The tonal ranges of amphibians have not been measured. Wever and Bray [28] observed a range of 120 to about 1000 cycles per second in the turtle (Chrysemys picta). Among birds the pigeon has a range of 100 to 10,000 cycles per second but with poor efficiency of reception as compared with mammals (Wever and Bray [29]). The increase in both range and sensitivity shown by the opossum pouch young as the supporting apparatus becomes increasingly differentiated appears to indicate that this apparatus has a role beyond mere support of the hair cells. The function suggested, namely, increasing the elasticity of the cochlear wall through resilient support of the reticular plate, together with the concept that the tectorial membrane rests on the reticular plate and is attached to the inner border cells and the cells of Hensen, gives meaning to the entire ensemble of the organ of Corti and its related structures, which must function as a unit.

Under this conception the pillars and the phalangeal cells would maintain a constant optimum pressure between the tectorial and basilar membranes, momentarily modifiable by movements of segments of the basilar membrane. If this be true, stimulation of the hair cells could be brought about by increased pressure beyond the normal or by pulling of the hairs attached to the tectorial membrane as the basilar membrane vibrates downward. A continuously intimate association of the tectorial membrane with the rest of the receptor mechanism would appear necessary to account for the extreme sensitivity of the organ of Corti to minute vibrations.

Comparison of the sound intensities required at different stages of development of the opossum (table) with the stages of development of the pillars, the tunnel and the supporting apparatus in the various coils (figs. 4, 8 and 9) appears to indicate that continued differentiation of this apparatus serves to increase the sensitivity of the organ of Corti. In the earlier stages of development, when the tunnel and the supporting apparatus are poorly developed, the sound intensity required to produce a response of 1 microvolt, as shown by McCrady, Wever and Bray,[6] is many times greater than that required in later stages of the opossum pouch young. Also the tonal ranges requiring the lesser intensities of sound at different ages of the pouch young lie in the regions assigned to these ranges on the basis of order of development, while the ranges both above and below these tones require a greater intensity. Likewise it will be noted from the table that up to 70 days the intensity required at all the tones tested, in general, decreases with age and therefore with differentiation of the organ of Corti. The 70 day pouch young is a partial exception to the trend, but the case appears to be one of slower individual development, as suggested by McCrady, Wever and Bray. In the 77 day opossum, while the tone of 2000 cycles per second requires the least intensity (— 5 and — 8 decibels) of any of the stages studied, the peak receptivity has shifted to 7000 cycles per second at — 23 and — 26 decibels for the left and right ears, respectively. McCrady, Wever and Bray reported a similar increase in sensitivity in older stages (78 to 82 days) of the Mexican opossum at the 7000 cycle range, and in their later report they stated that this zone is the point of maximum sensitivity for the adult opossum also. The maturing of the spiral organ in the lower part of the basal coil presents the most obvious explanation.

The interpretation that the organ of Corti increases sensitivity is strengthened by the fact that in the pigeon, which, like other birds, has no pillars or tunnel, Wever and Bray found a markedly low efficiency of the cochlea as a transmitter of sound. This is true in spite of the fact that birds have many more rows of hair cells at a given level of the papilla basilaris than have mammals, as shown by Held.[11] The organ of Corti must therefore be largely responsible for the greater efficiency of the mammalian cochlea, although the differences between the ossicles of the mammalian middle ear and the columella of birds must not be omitted from consideration.

Wilska [30] recorded amplitudes of vibration of the human tympanic membrane producing audible tones, ranging from 1830 millimicrons at 45 cycles per second to as small as 0.0045 millimicron at 3600 cycles per second. Ray-

28. Wever, E. G., and Bray, C. W.: Auditory Nerve Responses in the Reptile, Acta oto-laryng. **16**:154-159, 1931.

29. Wever, E. G., and Bray, C. W.: Hearing in the Pigeon as Studied by the Electrical Responses of the Inner Ear, J. Comp. Psychol. **22**:353-363, 1936.

30. Wilska, A.: Eine Methode zur Bestimmung der Hörschwellenamplituden des Trommelfells bei verschiedenen Frequenzen, Skandinav. Arch. f. Physiol. **72**:161-165, 1935.

leigh [31] many years ago had pointed out that only minute amplitudes were necessary. With Wilska's results as a basis, Stevens and Davis [32] have computed the displacement of the basilar membrane at near 3000 cycles as less than 1 per cent of the diameter of a hydrogen molecule. It would be difficult to conceive of so infinitesimal a displacement being transmitted through the organ of Corti to the hair cells so as to cause them to impinge against, or pull from, the tectorial membrane with sufficient force to produce a piezoelectric effect even if the whole system had the incompressibility of steel. Since this must be far from the case in the organ of Corti by reason of the structural arrangement of the supporting apparatus described, and also in the tectorial membrane because of its structure, one may be allowed to question the vibration factor of the basilar membrane as the sole cause of hair cell stimulation. This does not deny movement of the basilar membrane in response to vibration in the perilymph but merely raises the question as to the primacy of such movement as the stimulus-producing factor.

Békésy [33] made a simplified model of the ear in the form of a brass box with a medial partition also of brass. Part of the partition, however, was made of an elastic membrane, representing the basilar membrane. This investigator then determined by stroboscopic illumination the form of oscillation of the membrane to various sound frequencies. Standing waves were produced with several nodes, the internodal intervals being of different lengths and increasing from the base toward the apex. Békésy subsequently studied the human ear by observing the oscillations of the basilar membrane with a microscope through a hole in the bony cochlea, using stroboscopic illumination. He extended the validity of his earlier experimental results to the human cochlea.

Reboul [34] computed by mathematicophysical formulas the propagation of concussions in a column of fluid, applying the laws of the mechanics of fluids. For the sake of as great simplicity as possible, he assumed that the scala vestibuli is a conical tube in which the fluid (perilymph) is periodically compressed and distended by oscillatory movements of the membrane at the oval window. If the vibrations of compression are so rapid that they cannot be transmitted through the narrow helicotrema to the scala tympani, the oscillations are confined to the scala vestibuli, which is limited above by a solid wall, the bony cochlea, and below by an elastic wall, the basilar membrane.

Basing his equations on the propagation of the vibratory disturbance in a column of fluid contained in a tube with elastic walls, Reboul showed theoretically that for high tones the basilar membrane undergoes maximal displacement at a point which is a function of the frequency of vibration.

Comparing his results with the experimental observations of Békésy, Reboul stated that at the lower frequencies, toward the apex, the basilar membrane is displaced "like a vibrating reed," while at higher frequencies, near the base, on the contrary, movements of maximal amplitude are located at specific points on the membrane. Reboul's curves based, as he stated, on the smallest possible number of hypotheses, provide a possible explanation for the fact that the ear behaves as if it contained numerous small resonators, each tuned to a specific frequency, but suggest that the real explanation may lie in the fact that the oscillating pressure does not reach the same amplitude at all points along the cochlear duct but attains maxima at points determined by the frequency of the stimulating sound and the elasticity of the wall.

The evidence for tonal analysis in the cochlea has become so formidable, especially in view of the results of Ades, Mettler and Culler,[35] that the telephone theory so far as it expresses absence of cochlear analysis may be omitted from consideration in discussing our results on the opossum. These results, however, should be viewed against the background of the various conceptions of the cochlea as the analyzer. It must be stated at the outset that most previous discussions have almost entirely omitted from consideration the pillars of Corti and their related structures in the cochlea save as support for the hair cells, giving chief attention to the basilar membrane and the hair cells.

Our investigations show that the appearance of function of the organ of Corti as indicated both by reflex tests and by the oscillograph is closely associated with the development of the supporting apparatus and the tunnel of Corti. If, as previously suggested, we may regard this apparatus as a cushioning and tension mechanism supplementing and refining the elasticity of the basilar membrane on which it rests, some of the difficulties in arriving at a rational

31. Rayleigh, J. W. S.: The Theory of Sound, ed. 2, London, Macmillan & Co., 1894.

32. Stevens and Davis,[16] p. 56.

33. von Békésy, G.: Ueber den Knall und die Theorie des Hörens, Phys. Ztschr. **34**:577-582, 1933. Reboul.[34]

34. Reboul, J. A.: Theorie des phénomènes mécaniques se passant dans l'oreille interne, J. de phys. et le radium **9**:185-194, 1938.

35. Ades, H. W.; Mettler, F. A., and Culler, E. A.: Effect of Lesions in the Medial Geniculate Bodies upon Hearing in the Cat, J. Physiol. **125**:15-23, 1939.

explanation of the inner ear may be removed. Since histologists have described the pillars of Corti as so interlocked as to make individual movement impossible, the vibrations of specific positions of the basilar membrane postulated by the resonance theory cannot be transmitted to specific hair cells. In the opossum pouch young the basilar membrane is developed throughout the length of the cochlea quite early. It does not appear to be any different in sections of the nonfunctional 29 day opossum and those of the 48 day animal as compared with those at subsequent ages, after function has been established, although special methods of technic might show differences in its fibers. However, so far as we can judge from the material at hand, if it vibrates at all, there is no reason why it should not vibrate much earlier than 48 days. There are, in contrast, striking changes in the organ of Corti as described in the earlier part of this paper.

If these changes may be interpreted as completing the differentiation of the duct system of the auditory apparatus as elastic tubes in which waves in the perilymph and the endolymph can become effective as stimulators when the proper degree of differentiation is brought about, then we can ascribe a function to each of the parts of the complex auditory mechanism, instead of giving the basilar membrane alone the stimulating function. In such a conception pressure in the perilymph of the scala vestibuli, transmitted through Reissner's membrane and the endolymph and localized according to the pressure gradients determined by the frequency of the sound wave, would impinge on the tectorial membrane and, through it on the hair cells. Assuming that the tectorial membrane is attached to the organ of Corti and that the cilia extend into this membrane, no primary motion of vibration of either the basilar or the tectorial membrane would be necessary to stimulate the receptors, since the stimulus would be a localized concussion. Whether or not this conception is capable of experimental approach, it has the advantage of taking into consideration all of the anatomic factors of the cochlea.

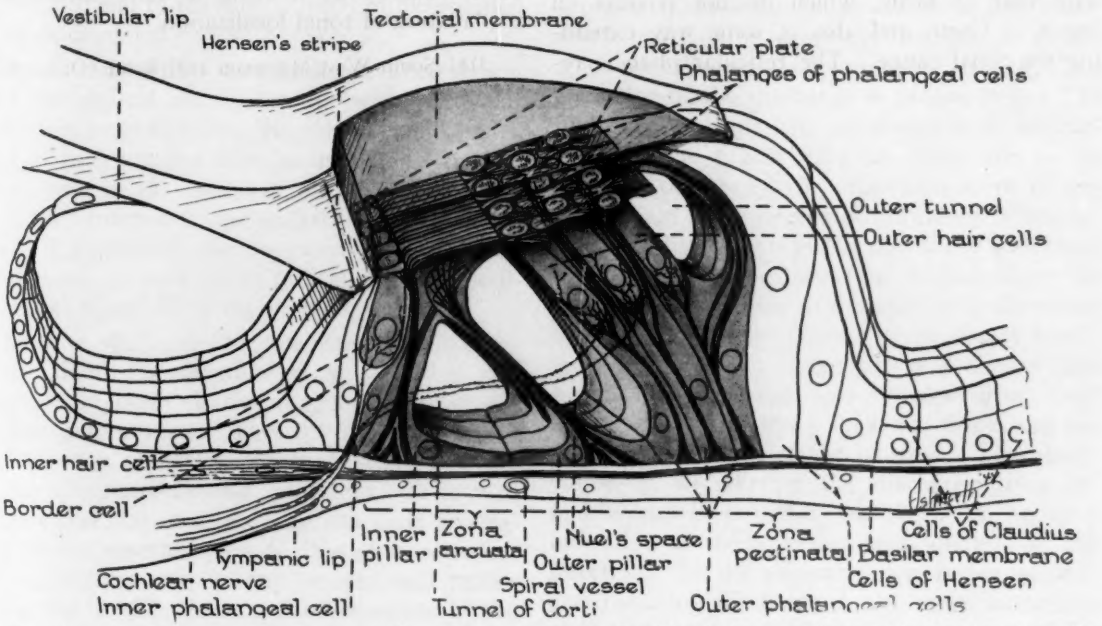


Fig. 12.—Semidiagrammatic representation of the organ of Corti and the tectorial membrane, based on the interpretation that the latter is attached along Hensen's stripe and at its outer margin. The supporting apparatus, reticular plate and hair cells are shaded. A portion of the tectorial membrane is represented as cut away to show more clearly the reticular plate, the phalanges and the ends of the hair cells. The remainder is depicted as translucent. The pillars of Corti and the outer phalangeal cells show the arrangement of the tonofibrils (black lines) and their manner of spreading in the head processes of the pillars, in the phalanges and below the basal ends of the hair cells. Adapted from Retzius, Held, Testut, Shambaugh and others.

## SUMMARY AND CONCLUSIONS

The earliest differentiation of the organ of Corti to an apparently functional stage was found in the upper part of the basal coil and the adjacent lower part of the medial coil. This differentiation consists in an elaboration of the pillars of Corti, the tunnel, the phalangeal cells and the reticular plate, their condition then approaching adult structure, and in enlargement of the hair cells. As the opossum continues to develop, the differentiation of the organ of Corti extends both

apically and basally from this initial zone. Pari passu, there is an increase in total range from an initial zone of 1000 to 1300 cycles to a range of 200 to 26,000 cycles per second. A lowering of the sound intensity required for response to notes of given frequency also accompanies development and appears to be correlated with the histogenesis of the elements of the organ of Corti.

The differentiation of the organ of Corti, especially that of the pillars and the supporting apparatus, is interpreted as gradually modifyng and refining the elasticity of the basilar membrane, thereby making the mammalian cochlea more efficient as a sound receptor, compared with that of birds, which do not possess an organ of Corti, and also in some way extending the tonal range. The reticular plate is regarded as a resilient surface on which the tectorial membrane rests and through which the hair cells project. Momentary modifications of its tension, brought about by waves in the basilar membrane, are suggested as a factor in the phenomena of tone analysis.

Because the structural characteristics of the adult cochlea, as well as the phenomena of differentiation and of receptivity of the developing organ as shown in the opossum, leave much to be explained under the conception that the tone-analyzing mechanism is composed of a series of indivdual resonators in the basilar membrane, some other physical principle, possibly similar to the theoretic waves of Reboul, should be considered as offering a more satisfactory explanation of tonal localization.

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# INDICATIONS, PROCEDURES AND RESULTS IN THE SURGICAL MANAGEMENT OF MASTOIDITIS

## A REVIEW OF THIRTY-THREE CASES

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NEW YORK

In this paper I shall consider the surgical treatment of the mastoid process involved in acute and chronic purulent otitis media, relate a few impressions gathered while a resident at the New York Eye and Ear Infirmary and attempt to add to the general fund of information already compiled on the subject.

I shall consider the simple, the modified radical and the radical mastoidectomy with particular reference to indications, procedures and results. My information has been accumulated from my experience in the clinics of the New York Eye and Ear Infirmary, particularly in 33 cases in which I performed mastoidectomy. Of these 33 operations, 14 were of the radical, 4 of the modified radical and 15 of the simple type.

First, I shall consider the simple mastoidectomy. Here the duration of the discharge and the date of onset of the symptoms are of the utmost importance. The distinction between the duration of otorrhea and the time of onset of the symptoms is also important. It is well known that the otorrhea may not start spontaneously for several hours or days after the onset of early symptoms; it may be less well recognized that a fully developed involvement of the mastoid process requiring surgical intervention can and does occur in the absence of any discharge and in the presence of a nearly normal drum head. It is my opinion that surgical intervention in mastoiditis following acute purulent otitis media need not be considered until three weeks after the initial onset of symptoms, which are fulness, pain, loss of hearing, headache, possibly discharge and tinnitus; any mastoidal pain or tenderness observed prior to that time is, I believe, due to edema in the cells of the mastoid process. The one noteworthy exception to the rule is in the case of an infection with pneumococcus type III, when surgical mastoiditis must be ruled out at once.

In regard to the discharge three points should be considered: the amount, the character and the presence or the absence of pulsation. Of the three, I believe the amount to be of the greatest diagnostic aid. One becomes accustomed to the amount of discharge to expect from uncomplicated acute purulent otitis media. Without much difficulty it becomes possible to discern a welling up of discharge after drying of the ear in the presence of an infection of the mastoid process. This is commonly known as the "reservoir" test. It is especially helpful in infants when the other signs are impossible to elicit. The character of the discharge is of less help. The foul odor so commonly associated with destruction of bone I believe is too often due to the presence of saprophytic organisms to be of any reliable aid. The degree of purulency is helpful, for if the discharge is purely mucoid, it is strongly suggestive that the infection is limited to the middle ear, especially to the vicinity of the eustachian tube. Actual degrees of purulency are of much less benefit. I have seen several ears from which the discharge was mucopurulent (and mostly mucoid at that) in which there was extensive destruction of the mastoid. The observation as to whether the discharge from the middle ear is pulsating or not is an accurate indication of the acuteness and intensity of the infection. In the presence of a rather profuse and pulsating discharge I feel more immediate concern for the possibility of involvement of the mastoid process than when there is an equal amount of discharge but no pulsation.

In my opinion one of the greatest aids in determining involvement of the mastoid bone is the amount of hearing loss. The loss with involvement will almost always be greater than one would expect from uncomplicated purulent acute otitis media. It is usually of the middle ear or conduction type, but in the presence of a severe infection, i. e., with Pneumococcus type III, or in the presence of the fulminating mastoiditis following scarlet fever or other virulent streptococcic infections it is often a nerve type. Loud tinnitus is also of contributory help.

In the endeavor to prove or disprove the presence of an involvement of the mastoid process mastoidal pain, or headache, and mastoidal tenderness are of value. As regards pain, one must be aware of great variation between patients in

the expression and the interpretation of pain. The same holds true for the eliciting of tenderness in the region of the mastoid process. In attempting to elicit this symptom one should be on the lookout for a palpable lymph gland in the region of the mastoid process. Such a gland is not infrequently present because of the infection of the ear and when palpated may well evidence a tenderness which is misleading. It is my custom to demonstrate mastoidal tenderness by pressure over the tympanic antrum, the emissary vein and the tip of the mastoid process.

The value of the appearance of the tympanic membrane in determining the presence of disease in the middle ear is universally recognized. In determining the presence of disease in the mastoid process, however, I consider the status of the tympanic membrane per se of little help. In fact, as suggested previously, I have encountered instances in which the appearance of the tympanic membrane was misleading. It is not uncommon for the disease to pass through the middle ear, so to speak, directly into the mastoid process without showing any of the signs of suppuration of the middle ear. In these cases there will be only minimal changes in the drum head, consisting of alterations or absence of the light reflex, some retraction or possibly some moderate injection and fulness of Shrapnell's membrane. Likewise, I do not consider the amount of tympanic membrane present as an important indication for or against simple mastoidectomy. Sag of the superoposterior wall of the external auditory canal is a significant sign of proved reliability.

The use of the roentgenogram as an aid in trying to establish the condition of the mastoid process is unquestionably of immense value. Yet I think it a mistake not to recognize the limitations of roentgen examination. To rely entirely on this in deciding on surgical treatment is dangerous. For several reasons roentgen examination is subject to inaccuracies. An area of bone destruction may be reported when, in reality, the area described is an unusually large cell. Points of destruction of the intracellular trabeculae may actually be visualized, but this damage may have occurred during a previous infection. Confusion often arises also in interpreting roentgenograms of the unusually pneumatic mastoid bone. A diseased mastoid process of this type may appear the same as the healthy one because the areas of rarefaction and destruction are especially difficult to discern when by nature the mastoid bone is highly pneumatized. Some have reported alterations in roentgen findings because of the use of sulfonamide compounds. My colleagues and I have not found it necessary to report roentgen evidences of mastoiditis worse than they actually appear in cases in which the patient has received sulfonamide drugs. With the possibilities of error in mind, we are accustomed to regard the roentgen findings as a valuable aid but only as a part of the entire picture derived from clinical findings, smears and cultures, examinations of blood, hearing tests and other studies. If in doubt as to whether a mastoid process should be examined roentgenographically or not, I believe it is best to examine it, because even if the plates show no pathologic change there is then something with which to compare future plates; furthermore, the anatomic configuration of the bone has been established.

It has been my experience that too little attention has been paid to the general condition of the patient. In cases of acute mastoiditis the general appearance of serious illness is quite apparent. In cases of smoldering infection of the mastoid process the general condition is less striking but nevertheless definite. The patient appears chronically ill; there is a history of easy fatigue and lack of energy; often there are anorexia and mental apathy.

In discussing the indications for simple mastoidectomy it is necessary to say something regarding the use of the sulfonamide drugs. A great deal has been published about the masking effects of these drugs on acute mastoiditis. Our experience has been a good deal the same. As I mentioned before, however, we have not observed the confusion in roentgen findings reported. It has not been our experience that administration of a sulfonamide compound will cause the roentgenogram to show no destruction of bone whereas in actuality there is. In general, if sulfonamide compounds are given, the detection of the onset of mastoiditis becomes much more difficult. One can no longer rely on the usual aids of diagnosis. The discharge may have ceased entirely, mastoidal pain and tenderness may have disappeared, the temperature and the white blood cell count may have returned to normal; still the destruction of the mastoid process may be continuing. In certain cases, valuable information can be obtained by stopping the administration of the sulfonamide drug and awaiting results. In some instances, with the cessation of chemotherapy, pain, purulent otorrhea, tenderness over the mastoid process, fever and leukocytosis will return, proving that the mastoiditis is still active. Some have even reported sinus thromboses without the slightest signs or symptoms suggesting such ensuing pathologic change in Pneumococcus type III infections. I believe the only safe way to control the situation is to examine the patient repeatedly, both clin-

ically and roentgenographically, during the course of the use of the drug and at less frequent intervals for six months after its administration has been stopped. On several occasions we have administered sulfadiazine to patients when true surgical mastoiditis had been firmly established. In a high percentage of cases there was evidence of regeneration of bone as shown by roentgenogram at the end of a six month period; there have been no instances of recrudescence of the disease of the mastoid process. In 3 cases in which Pneumococcus type III was the offending organism, there was evidence of regeneration of bone as mentioned, and the ear was dry, but the marked loss of hearing and the annoying tinnitus persisted, as severe as before therapy was instituted. It is my own opinion that when true surgical mastoiditis has been established, surgical treatment is still the therapy of choice. I believe that the chances of later complications are much lessened and also that the chance for recovery of hearing is greatly enhanced. Furthermore, I am convinced that the safest and best time to use the sulfonamide drugs is before the destruction in the mastoid bone has been able to get under way.

Besides using the simple mastoidectomy for the acute and the subacute mastoiditis, as indicated by the foregoing discussion, I have also had encouraging results using the so-called complete simple mastoidectomy in selected cases of chronic otitis media. My associates and I have found this procedure to be of greatest value in cases in which the hearing has remained good and in which there is no cholesteatoma and the middle ear is, for the most part, free of granulations. If granulations are present, we select those cases in which the disease is more or less limited to the epitympanum. I like the "complete" simple operation for all cases in which I think simple mastoidectomy is indicated, whether the disease is acute, subacute or actually chronic. In view of this I shall describe only the latter when discussing the operative procedure. In addition, before discussing operative procedures I should like to say that in all cases to be referred for surgical treatment it is important that any abnormal conditions of the nose and the throat be remedied when this is considered necessary.

Prior to operation, all patients who are to undergo the "complete" simple operation are given a hearing test, a roentgen examination of the mastoid processes, a complete study of the blood, a routine urinalysis and an examination of the heart and the lungs. We use the open drop ether method of inducing anesthesia in all our patients. The area behind the ear, the pinna and the external canal are cleansed with iodine and alcohol in that order. We use the postauricular incision exclusively, although the endaural approach is not held in disfavor. The periosteum is then reflected away from the underlying cortex and the spine of Henle is identified. With the gouge, the mastoid cavity is entered in that region, in an attempt to avoid injury to the sigmoid sinus. The antrum is then identified and a probe passed into the middle ear. Following this, the antrum is enlarged, and the horizontal semicircular canal is identified. With the latter used as a guide in regard to the depth of the facial nerve, the cells of the mastoid process are exenterated to the dural and the sinus plate. At the tip the digastric ridge is a great help in establishing the depth of the facial nerve. This portion of the operation having been completed, this usual procedure is converted into a "complete" operation by removing the cortex and any cells present in the region of the zygoma to the extent of completely exposing the short process of the incus. The ridge of the canal of the facial nerve is then thinned down everywhere but particularly in the region of the incus, to open the epitympanum wide. A cigaret drain is placed securely in the epitympanic region, and the incision of the skin is closed with clips almost completely. I do not adhere to the use of a powdered sulfonamide compound in the mastoidectomy cavity. It is my opinion that it prolongs postoperative drainage, and is not necessary for prompt healing. In 1 instance I was strongly suspicious that the introduction of the powder was directly responsible for a breaking down of the entire wound that made plastic closure necessary. Before putting on the classic mastoidectomy dressing the external canal is securely packed with dry serrated gauze. My preference is to change the dressing and canal packing daily. I remove the cigaret drain as soon as the ear is dry and stays dry for forty-eight hours. The clips are removed on the third postoperative day, and the patient is allowed up on the fourth postoperative day if there are no indications to the contrary.

I shall report a series of 15 cases in which simple mastoidectomy was done. In 2 of the 15 it was bilateral, while in the remainder only one ear was operated on.

Of the total number of patients, 10 were males and 5 were females. The average age was 10.5 years, the youngest patient being 5 months old and the oldest 32 years of age. The average duration of the disease of the ear as determined by the onset of any symptom referable to the ear was eighteen weeks, but in the majority of cases it was about five weeks. The shortest duration of disease was three weeks; the longest,

one and one-half years. In regard to those cases in which the disease had lasted one year or more, I do not mean to imply that the discharge had been persistent but rather that it had recurred sufficiently frequently for one to be sure that the underlying mastoiditis could never be considered as quiescent. All the patients were treated by "complete" simple mastoidectomy as described before. The predominating organism was the hemolytic streptococcus; there were no cases of Pneumococcus type III infection.

There was a wide variation in the length of time required for the ears operated on to become dry. The range was from a minimum of twenty-four hours to a maximum of five weeks. The average was sixteen and one-tenth days. One ear did not dry and required the modified radical operation. In all cases but 2 the tympanic membrane either had no true organized perforation or a very small, almost pinpoint defect. Of the 2 cases, in one there was intermittent otorrhea for over a year with a large posterosuperior perforation that never completely healed after operation but became much smaller, while in the other there was long-standing otorrhea with an anteroinferior perforation which never healed even after the modified radical operation. All the other patients except 1 eventually had intact drums.

As far as hearing was concerned the results were encouraging. Five patients were so young as to make an audiogram valueless. Preoperative audiograms were not secured from 2 of the 10 remaining patients because of the urgency of operation. In determining the percentage loss, the frequencies of 512, 1024 and 2048 were used, since they are the ones most involved in ordinary conversation. All of the 8 patients thoroughly studied for hearing before and after operation showed a definite gain in hearing with the exception of 1. This patient had an initial loss of 2.4 per cent and, following operation, had a loss of 12 per cent. The exact cause of this unfortunate result was not determined, but it seems likely that the ossicles were displaced at the time of operation. The remainder showed an average gain of 7.4 per cent. All had good hearing for conversation in the affected ear postoperatively. The 2 patients who had no test before operation had only a 5.2 per cent and a 2.6 per cent loss after surgical treatment, and both patients had good conversational hearing in the ear operated on. The smallest hearing gain after operation was 1.6 per cent; the greatest was 29.2 per cent.

I should now like to offer a report of 3 cases:

J. W., a 24 year old man, was first seen in our clinic after the right ear had been draining off and on for one year. He complained of a definite hearing loss in that ear and of a foul discharge. For the week prior to the visit to the clinic he had noticed some pain. Examination showed a small amount of foul discharge overlying the drum. The tympanic membrane was in good condition but was excoriated and without a light reflex and was considerably injected throughout. Medially and inferiorly there was a small perforation through which a small amount of granulation tissue extruded. The roentgen examination was completely inconclusive as to any disease in the mastoid bone although there was a slight suggestion of erosion in the region of the antrum. The remainder of the examination of the ears, nose and throat gave negative results. A hearing test showed only a 4 per cent loss for the right ear. Chiefly because of the excellent hearing but also because of the relative good condition of the middle ear and tympanic membrane, we decided to try a "complete" simple mastoidectomy. The routine preoperative work-up disclosed nothing remarkable, so three days after the patient's first visit to the clinic I performed the "complete" simple operation on his right ear.

At operation the bone was found to be well pneumatized and without pathologic change except for necrosis of a few cells in the immediate vicinity of the antrum. There was a meager amount of granulation tissue in the aditus coming from the middle ear. Approximately three weeks later the postauricular drain was removed even though there was still a scant foul discharge from the middle ear. The patient was instructed to clean the ear with hydrogen peroxide three times a day. I saw him almost daily, at which time I cauterized the small bit of granulation tissue extruding through the inferior part of the drum. With this treatment, the granulations melted away, and the tympanic membrane healed completely. The ear was completely dry in five weeks. A hearing test at that time showed only a 2.4 per cent loss. At the time of writing, five months after operation, the ear is still dry, and the patient is completely asymptomatic.

V. M. is an 8 year old boy. When he was first seen in our clinic the right ear had been draining steadily for one month, following an acute infection of the upper respiratory tract, but the patient stated that the ear had discharged "on and off" for years prior to the present acute episode. There was no sag to the superior wall of the external canal, and the drum was pale and intact except for a pinpoint-sized perforation anteroinferiorly, from which exuded a profuse, not foul, thick purulent discharge. It was not pulsating. The patient did not complain of pain, and there was no tenderness over the mastoid process. No sulfonamide drugs had been administered. Roentgen examination showed the right mastoid process to have little cellular structure; there was some destruction of a few cells in the vicinity of the tip of the process. A hearing test done before operation disclosed only a 2.4 per cent loss in the involved ear. Again because of the excellent hearing and the good condition of the middle ear and tympanic membrane and also because of the age of the patient and the long duration of his disease, it was decided to try a "complete" simple operation.

At operation, the mastoid process was found to be poorly pneumatized, but the cells present were scattered diffusely throughout. In all parts of the mastoid process there were areas of sclerosis adjacent to areas of necrosis. When the dressing and the packing in the canal were changed for the first time in twenty-four hours, the middle ear was completely dry, and although I packed the canal for several days thereafter to be on the safe side, the ear never discharged again. Hearing was tested, and the hearing loss this time in

the ear operated on was 12 per cent, a considerable increase. This is difficult to explain, but it seems likely that, all precautions notwithstanding, the ossicles must have been displaced at the time of operation. This loss, however, did not deprive the patient of good hearing for conversation. At the time of writing, approximately two months after operation, the patient is asymptomatic, and the right ear is dry.

F. V. is a 3 year old boy. Five months prior to his first visit to the clinic he had an acute infection of the upper respiratory tract which was followed by pain and discharge from the right ear. He was treated by the family physician, but in spite of all therapy the ear continued to drain. When seen by us, he appeared chronically ill, with a foul and moderately profuse discharge from the right ear. There was no tenderness over the mastoid process, and the patient did not complain of any pain. The tympanic membrane was excoriated and diffusely injected, with a small perforation in its anteroinferior part. The left ear appeared normal; there was marked hypertrophy of the tonsils and adenoids. Roentgenograms of the mastoid processes showed an acellular mastoid bone with some erosion of the periantral structures.

The "complete" simple mastoidectomy was decided on. At operation the mastoiditis was found to be well developed. The pathologic change, however, was well localized to the antrum. There was considerable periantral erosion with granulations and pus under pressure. When the zygomatic region was worked out, the granulation tissue was seen to fill the epitympanum as well as the antrum. Three weeks after operation the right ear was still putting out a foul and profuse discharge. Tonsillectomy and adenoidectomy were then done. This also failed to clear the ear. At the end of the fourth postoperative week the patient was sent home to be followed in the clinic. The mother was instructed how to instil a 0.5 per cent solution of an ephedrine salt intranasally and how to clean the child's ear with hydrogen peroxide three times a day. Such treatment was of no avail, and approximately two months later it was decided that the modified radical mastoidectomy would have to be performed. I shall discuss this case further when I present my results with that operation (page 254).

I have presented here 3 cases selected for the "complete" simple operation. In 2 the mastoiditis was definitely chronic; in the remaining case it was in the subacute class.

The first case was ideal in every respect. With the most conservative operation, the chronic otorrhea was cleared, with the best possible results in hearing. In the second case, the otorrhea was successfully controlled, but there was a considerable amount of postoperative hearing loss. This in my estimation clearly points out the great care which must be exercised while the "complete" operation is being done. In this case, as in the majority, the epitympanum was filled with granulations completely hiding the ossicles from view. In the endeavor to uncap the epitympanum, it is easy inadvertently to dislodge the incus. To avoid this, one must keep the bottom of the curet always facing the incus and curet away from it. In this regard it is also most important not to insert the curet into the aditus but merely to engage the edge of the portion to be removed. If this is religiously followed, no harm can possibly come to the ossicles. In the third case the operation failed in its purpose completely. In a certain number of cases, of course, varying with the skill of the operator and the care in the selection of cases, this will happen. However, as I mentioned before, no harm is done because the operation can be readily converted into the modified radical or even the radical mastoidectomy if desired.

In the surgical management of chronic otorrhea we use the modified radical and the radical mastoidectomy. For certain selected cases we use the "complete" simple operation, as discussed. The questions confronting the surgeon treating chronic otitis media are: (1) Is surgery indicated; (2) if so, should the modified radical, the straight radical or the "complete" simple procedure be used?

I think both of these questions can be answered in general by saying that the treatment of chronic otitis media, whether surgical or medical, should aim first to give the patient every advantage in behalf of his personal safety and secondly to give him the best ear possible from the standpoint of comfort and function. (The limits of this paper prohibit a discussion of the indications for conservative therapy as opposed to those for surgical intervention.) I believe that the indications for the "complete" simple mastoidectomy in cases of chronic otitis media are essentially those for the modified radical approach, and that the choice rests with the surgeon who must decide in the light of his past experience and what he finds at operation. I feel that the former is the procedure of choice with the very young patients (below 15 years), while with older patients the modified radical operation is the better, since the risk of possible reoperation is lessened.

I believe that the status of the hearing is of prime importance in deciding on the modified operation. If the patient has conversational hearing in only one ear, and that is the ear to be operated on, I consider that the patient deserves the modified operation regardless of whether the operator believes a dry ear will result or not, unless, of course, the future general health or the life of the patient is thereby threatened. If the procedure fails, it can always be easily converted into the radical mastoidectomy. If the patient has good conversational hearing in both ears, then I think the modified operation should be definitely considered, although it is not imperative. If the saving of hearing is not a factor, I would not rule out the operation on that basis alone. If the middle ear is in good condition and free from polyps and granulations,

and if there is a large segment of drum remaining, I believe this operation preferable to the radical, even though the hearing is not a factor. If the middle ear can be left undisturbed, the convalescence is shortened, the discomfort of a discharging eustachian tube is often avoided, the constant care required for the cavity left by a radical operation is unnecessary, and the patient is generally less ear conscious, so to speak. In my experience it is for the most part unwise to expect an actual improvement of the hearing after the modified operation. The best to be expected is that the level of hearing already present will be maintained or at best reduced so little as to avoid conversational loss.

The presence of a generous amount of ear drum is desirable if this type of procedure is contemplated. On the other hand, if everything else points to the modified operation as the procedure of choice, I favor it even if there is no drum present. This is especially true if the question of preserving hearing enters the picture only slightly. In my experience, in certain patients at least, no matter how hard one may try to keep granulations off the middle ear after the radical mastoidectomy, they will form and quickly reduce the hearing below the serviceable level. If the modified mastoidectomy is done in the absence of tympanic membrane, there will doubtless be cases in which a certain amount of odorless mucoid discharge will persist indefinitely after the operation, but from the patient's standpoint I think this preferable to a dry ear without any serviceable hearing.

✓ As I have intimated, the preoperative condition of the middle ear is important in deciding on the correct operation. If the entire middle ear is choked with granulations or polyps and most of the drum is destroyed, the modified operation is contraindicated. In such a case one would expect the hearing to be below the range of conversation anyway. If, however, the granulations occupy only the epitympanum and the lower segment of the tympanic membrane remains, I believe it preferable to do the modified radical mastoidectomy. In the presence of cholesteatoma or of purulent or circumscribed labyrinthitis I do not feel it wise to temporize with the modified mastoidectomy.

In attempting to make a decision as to the advisability of surgical intervention it has been my experience that the roentgenogram is of less help in a case of chronic purulent otitis media than in a case of the acute condition. One obvious exception to this is in the diagnosis of cholesteatoma. Further, the roentgenogram is of definite benefit in learning the anatomic configuration of the mastoid process prior to operation, with special reference to the position of the lateral sinus, the type of bone and the location of areas of destruction if seen.

The preoperative preparation for a patient to have the modified radical operation is the same as that for one to have the simple mastoidectomy outlined in foregoing pages. In making the incision I have come to like it as close to the pinna posteriorly as possible. In my experience the healing is as satisfactory as with the incision made more posteriorly, and the cosmetic result is much more desirable. It is helpful in this procedure to carry the initial postauricular incision horizontally and forward to a point about an eighth of an inch (0.3 cm.) above and in front of the auricle at its superior attachment. Following the incision, the periosteum is incised, and the soft parts are reflected from the underlying cortex. From here on the Blackwell procedure is used almost exclusively. The purpose of this operation in Blackwell's own words "is to thoroughly aerate, drain and expose the antral region as otherwise this infected focus will remain and reassert itself."

As related before in describing the simple mastoidectomy, the cortex is removed with a gouge and the antrum entered. It is then enlarged to the fullest possible extent. The bone in the zygomatic region is removed, and the posterior bony wall of the external canal is lowered. Then the external attic wall is removed, and the posterosuperior bony wall of the external canal is reduced in thickness until the facial ridge is reached, leaving only the epitympanic ring arching above the top of the drum from the posterior to the anterior wall of the external canal. The short process of the incus should now be clearly visible. The aforementioned epitympanic ring is now removed, exposing the malleus and the incus. The removal of this segment provides excellent drainage for the epitympanic and antral regions, where the seat of the infection is almost always located. A flap is then cut (I use the modified Ballance method) and is sutured in place. The postauricular incision is then closed completely with clips and the cavity is packed with iodoform gauze, care being taken to avoid placing the packing against the structures of the middle ear. A dressing for the mastoidectomy wound is then applied. The clips are removed on the third and the packing is removed on the second postoperative day. The patient is allowed up routinely on the third or fourth day. I like to keep a full dressing on the wound for about sixteen days in order to insure good position of the auricle. In hastening dermatization of the cavity

and in helping to reduce the amount of granulations present we have had gratifying results with the use of a pack impregnated with an ointment containing carbolfuchsin. Besides placing the pack in the cavity, I put it up against the drum, for in this way the middle ear cavity is obliterated and all drainage is forced to leave through the newly created opening in the epitympanum. When dermatization is well advanced, I discontinue the use of the aforementioned pack and have the patient cleanse the cavity with hydrogen peroxide three to four times a day.

In the series of patients under consideration, only 4 underwent the modified radical mastoidectomy. Since the group is so small, I think the data can be presented best by a table. All patients in this group were males.

It will be noted in the table that all the ears operated on were healed and dry in about seven weeks with the exception of 1. At the end of three months after the operation J. R. still had a profuse foul purulent discharge from the cavity and the middle ear. The reason is clear. He would come to the clinic for treatment only once a week and would not take the proper care of the ear at home. It has been my experience that such after-care is totally inadequate. I do not feel that the absence of tympanic membrane was responsible for the poor result. In his case the cavity never did dermatize completely, and this is a prerequisite for a dry ear. I have no record of his hearing since the operation, but I certainly would expect no improvement. In fact, it is doubtless worse.

On the other hand, H. W., with the proper postoperative care, did well. At the time of writing the right ear is completely dry, the middle ear is free from granulation tissue and the perforation has healed. He had atrophic rhinitis in an early stage, which is being treated also. It is interesting to note that he has a good result from the standpoint of hearing although the incus was intentionally removed at the time of operation.

At the end of seven weeks, D. R. had a dry ear, and the perforation of the tympanic membrane had healed. While his hearing for ordinary conversation in the ear operated on is perfectly satisfactory, yet by audiogram he has a 10.8 per cent increase in hearing loss. At operation the incus was inadvertently dislocated. It was, however, maneuvered back into place and left there. This disturbance most likely accounts for the poor result in the hearing. In the light of the case discussed previously it seems possible that the hearing would have been better had the incus, once dislodged, been removed completely. In our experience the removal of the incus seldom causes any serious impairment of hearing.

As stated before, F. V. was treated by "complete" simple mastoidectomy, but the foul otorrhea persisted. Approximately two months after the first operation the modified radical mastoidectomy was performed. As noted in the table, the ear was dry in about seven weeks. The small perforation in the anteroinferior part of the drum has persisted to the time of writing, and when the child has a cold there is a slight amount of odorless clear mucoid discharge. Although the child's general condition has improved markedly since the operation, I am in hopes that the improvement will continue to the point where the incidence of acute infections of the respiratory tract will be materially reduced. In order to be sure that the ear would be in good position after the operation, I left the large dressing in place two full weeks. Even so, when it was removed, the ear was found to be away from the head in the typical lop ear position. I am glad to say that the contraction of the scar tissue has been sufficient to pull the ear back into a normal position at the time of writing. The patient's age prevents audiometric studies of hearing, but from rather inaccurate clinical examination one would assume the hearing to be good for ordinary conversation.

We do not believe that there is such an entity as chronic otitis media per se but hold rather that every so-called chronic purulent otitis media is in reality a chronic infection of the mastoid process. True, in most cases the disease is associated with sclerotic bone, but there is always

*Data on a Series of Patients Who Were Treated by the Modified Radical Mastoidectomy*

| Patient | Ear | Age, Yr. | Duration of Disease | Time for Healing | Condition of Tympanic Membrane | Pre-operative Hearing Loss | Post-operative Hearing Loss |
|---|---|---|---|---|---|---|---|
| D. R. | L | 36 | 4 mo. | 7 weeks | Posterosuperior marginal perforation | 10.4% | 21.2% |
| H. W. | R | 17 | 2 yr. | 6 weeks | Posterosuperior perforation with granulations | 14.4% | 6.4% |
| F. V. | R | 3 | 7 mo. | 7 weeks | Anteroinferior perforation | ? | ? |
| J. R. | L | 17 | 4 mo. | Did not dry | Only superior part remained | 13.0% | ? |

to be found actual destruction of bone to some degree even if involving only the periantral region. I have discussed the use of the modified radical operation in these cases; now I shall consider the radical procedure.

This operation in my estimation should never be done with any hope of retaining serviceable hearing in the ear affected. Naturally, there will be instances in which the pathologic alterations will demand the radical operation regardless of the functional result to be expected. This will be discussed later. If, however, the ear can be made safe, even though not dry, by avoiding the radical operation, that should be done if by the radical operation the surgeon would destroy the patient's last vestige of conversational hearing. I have seen several patients who were treated by bilateral radical mastoidectomy, and none of them had serviceable hearing. By the same token, the patient who can hear conversation with an ear on which the radical approach was used is the exception.

Assuming that the hearing has been ruled out as a problem, I believe that the radical mastoidectomy is the procedure of choice when there is total destruction of the drum and the middle ear is filled with polyps or granulations. It has been my experience that in such an ear there is usually no serviceable hearing in any event. In the case of cholesteatoma I hold that the radical type of operation is the best. In the absence of signs of complications I think that the modified radical mastoidectomy might be attempted if by doing the radical mastoidectomy all serviceable hearing may be lost. If the modified operation is performed, the cholesteatomatous cavity can be reasonably satisfactorily watched and kept clean via the mastoid cavity. Frequent roentgen examination is mandatory. If there are signs of complications, i. e., labyrinthine involvement or intracranial disease, the radical procedure must be done, the hearing notwithstanding.

In cases in which serous labyrinthitis or perilabyrinthitis has been demonstrated, I do not think the radical mastoidectomy is indicated on that basis alone. On the other hand, in the presence of circumscribed or purulent labyrinthitis I do not think any other procedure justified. In the case of purulent labyrinthitis, labyrinthectomy should also be done. In certain cases of chronic purulent otitis media the labyrinth will be found inactive to caloric tests. On that finding alone we do not routinely do labyrinthectomy at the time of the radical mastoidectomy.

With the exception of cases in which cholesteatoma is present, I feel that the roentgen findings alone will not be of much value as an indication for this operation.

When a tumor is to be removed from the ear, the radical approach is the one of choice. It is also necessary for decompressing or grafting in the horizontal course of the facial nerve. In certain cases in which the modified radical mastoidectomy has been done previously, it will be necessary to convert the cavity into a radical one to eliminate the disease.

In deciding whether or not to do the radical operation, it may be said in general that the type of pathologic condition present may never be considered alone but must always be considered together with the hearing present. The one factor must be weighed against the other at all times. Speaking of surgical procedures in general as used for chronic otorrhea, I have here again been impressed with the tremendous improvement in the general physical condition of the patients operated on. They gain weight, they lose their mental apathy and general easy fatigability, and their appearance obviously improves.

The preoperative preparation is the same as that already outlined with the exception that a caloric test is done as a routine. This gives one the status of the labyrinth before operating, which can be of inestimable value in case of an unfortunate turn of events following operation, i. e., labyrinthitis, onset of vertigo or any other symptom which would bring the condition of the labyrinth into question.

In the first few cases of chronic purulent otitis media in which I did the radical mastoidectomy I used a postauricular incision far back. This was done in order to place the scar in the hair as far as possible and also to avoid having the incision lie over the cavity. Later on in the series I placed the incision as near the auricle as is feasible and observed not only that healing is equally satisfactory but that the resulting scar is decidedly less noticeable. Following incision, the soft tissues and the periosteum are reflected away from the underlying cortex, and the mastoid antrum is entered in the region of Henle's spine. The antrum is then enlarged as much as possible, care being taken to avoid the sigmoid sinus, which is apt to be anterior in the sclerotic bone. It is also well to keep in mind the fact that in the sclerotic mastoid process the dural plate is apt to be low. The bone is then removed from the zygomatic region, and the posterior wall of the external canal is thinned down. The bridge is then removed, and the contents of the middle ear are carefully evacuated. In doing this one should take great care not to crush the paper-thin bone overlying the horizontal course of the

facial nerve. Care should also be exercised in removing the incus and the malleus not to dislocate the stapes. However, the danger of the latter is not as great as is generally believed, for the stapes is anchored into the oval window very securely by its ligament, and in forceful manipulation the crura of the bone will break before the footplate is dislodged. After the middle ear is cleaned out, the posterior wall of the external canal and the facial ridge are taken down to the level of the horizontal semicircular canal. The area previously occupied by the bridge is then further enlarged by leveling off the neighboring dural plate. To my mind, the two maneuvers most important to achieve a satisfactory postoperative result are: (1) taking down the hypotympanum; (2) removing the vertical overhang. Since the purpose of the operation is to convert the cavities of the middle ear and the mastoid process into one large cavity, into the shape of a funnel as far as possible, it stands to reason that this ideal cannot even be approached without first accomplishing the two steps mentioned. Removal of the hypotympanum should be carried out until the floor of the middle ear and the most distal part of the external acoustic meatus are on the same level. If the slightest dip remains, it will seriously embarrass the results. By the vertical overhang I refer to that portion of the facial ridge that projects forward over the oval window and promontory after it has been already sufficiently lowered. This should be removed completely. Great care should be exercised in curetting over the oval window; this is the area where the first portion of the descending part of the facial nerve lies and the bone is very thin. Working on the lower part of the facial ridge is accompanied by much less danger, since the facial nerve lies quite deep at that point. If these two procedures are carried out thoroughly, the middle ear will have the appearance of a shallow saucer, which is precisely the way it should look for achieving the best results. The eustachian tube, now in full view, should be curetted well to remove all infected mucosa and granulation tissue. In working in the middle ear the tendon of the tensor tympani muscle may be used as a guide to the beginning of the horizontal course of the facial nerve, since it is at that point that the nerve enters the middle ear on leaving the geniculate ganglion. I do not think it necessary to remove every vestige of granulation tissue from the middle ear at operation, for it has been my experience that what is left will either come out with the packing or slough out later during postoperative treatment. The next step is to cut the flap. As stated before, I use the modified Ballance procedure. The knife is inserted through the external meatus, and the initial incision is directed downward toward the feet. It is then directed posteriorly along the base of the inferior concha stopping short of cutting the posterior integument of the auricle. From there it is brought upward and somewhat forward to terminate at about the middle of the upper cartilaginous border of the inferior concha. The flap is then deprived of cartilage and reflected up into the mastoid cavity, where it is sutured in place with chromic catgut. To insure strong support, I suture it to the temporal muscle as far as possible. After securing the flap, the cavities of the mastoid process and middle ear are packed with iodoform gauze, and the postauricular incision is closed with clips. The standard dressing for the mastoidectomy wound is then applied. My own experience with grafts has been disappointing, but they are doubtless of value in the hands of those with more experience.

As with the modified radical operation, I like to change the dressing daily but I do not discontinue its use for about sixteen days after operation, to insure good position of the auricle. The clips are removed on the third day and the packing on the third to fourth day. The patient is allowed up on the fifth to sixth day if there are no indications to the contrary, and is discharged at the end of the first week if a follow-up clinic is available. The treatment of the cavity from then on is one of the most difficult tasks I have ever attempted. To keep the middle ear free from granulations, almost daily care is required. In my experience the treatment has been greatly facilitated by the use of a packing impregnated with an ointment containing carbolfuchsin as mentioned earlier. The packing should be changed about every other day. It is removed easily and with no discomfort to the patient. Following its removal, all granulations may be curetted away easily and have the consistency of soft butter. In my estimation dermatization is greatly facilitated by its use. In order to obtain the best hearing possible, the middle ear should be kept completely free from granulations, and the epithelium should be encouraged to grow directly over the bone. Particular attention should be paid to the region of the hypotympanum and the area formerly occupied by the bridge. As far as the mastoidectomy cavity itself is concerned, I do not see the necessity of keeping it clean to bone. In fact, in the case of a large cavity I believe the results will be better if granulation tissue is allowed to fill in the various depressions, thus leaving a smooth even surface when dermatization is complete. It has been my custom to anesthetize the cavity prior

to curettage with epinephrine hydrochloride and cocaine crystals. Doubtless just as good anesthesia can be obtained with the 10 per cent solution, but the use of it is somewhat more time consuming. As in the case of the cavity from the modified operation, after healing is well advanced, I discontinue the use of the carbolfuchsin pack and merely instruct the patient to clean the cavity with hydrogen peroxide three to four times a day. Cleanliness in itself will go a long way in keeping the formation of granulations at a minimum. Once the cavity is completely healed, it is important for the patient to continue to clean the ear and to come in for a check-up at regular intervals. If the cavity is not kept clean, a ceruminous deposit forms in the ear, the removal of which is frequently complicated by the cavity being denuded of epithelium. If this occurs, a foul discharge is bound to result and to remain until the area has once more healed. I instruct my patients to clean the ear at least once a week with hydrogen peroxide.

I should like to report on a series of 13 cases in which treatment was by the radical mastoidectomy. At the outset I should say that the over-all results have not been good. This I believe can be attributed to the fact that both the surgical technic and the postoperative care were new to me in the beginning and also to the fact that the general condition and the environment of the patients were not the best as far as encouragement of healing is concerned. The first is doubtless the more pertinent of the two, since the results did improve in the later cases.

The patients were 8 males and 5 females. The average age was 25.2 years. The youngest was 5 years, while the oldest was 44 years of age. The duration of disease showed a wide range. The average was seven and ninety-six hundredths years, with the shortest recorded duration being six months and the longest seventeen years. Eight left ears were operated on and 5 right ears, a difference of no practical significance in my opinion.

As far as the condition of the tympanic membranes and the middle ears was concerned, there was no essential difference. In all cases, the drum was entirely or almost entirely destroyed, while the middle ear was filled with granulation tissue. In a number of cases, polypoid tissue protruded into the external acoustic meatus from the middle ear.

Of the 13 ears, only 4 are completely dry, with totally dermatized cavities. Three more have cavities that are completely dermatized except for the small area around the mouth of the eustachian tube. In another group of 3, for one reason or another, the cavities never have completely healed and purulent discharge persists. In the remaining 3 cases operation was so recent that the cavity has not yet healed.

In regard to the last group mentioned, though there is obviously no point in discussing operative results, there is a case that I should like to report in particular:

R. F. is a young woman 23 years old. When first seen in our clinic she gave a history of having had a discharge from the left ear about ten years previously. With conservative therapy it cleared spontaneously. Six months prior to her first visit the left ear began to discharge again; this was not associated with any pain or headache until four days before we saw her, when she began to have pain in the ear and generalized pain on the corresponding side of her head. Two days later she first noticed weakness of the left side of her face. On examination she had a complete facial paralysis on the left side. It was of the peripheral type, but no loss of function of the chorda tympani nerve on the left side could be elicited with the usual tasting tests. There was response to a galvanic current, also good activity with a faradic current, best elicited at the region around the orbit on the lateral side. The external auditory canal contained a small amount of foul purulent discharge. The tympanic membrane was almost completely destroyed (all but Shrapnell's membrane), and the middle ear was choked with granulation tissue. There was no tenderness over the mastoid process. Roentgenograms of the mastoid processes showed the left one to be sclerosed, for the most part. A small focus of bone destruction in the region of the horizontal semicircular canal was described, also a small area medial to the superior semicircular canal directly beneath the petrous ridge. A hearing test showed a 20 per cent loss in the left ear. A caloric test proved that both labyrinths were active. The fistula test was negative. The remainder of the preoperative work-up gave essentially negative results. Twenty-four hours after the patient was first seen the radical mastoidectomy was done on the left side. Since response to the faradic current was present, the nerve was not uncapped. At operation there was pus under pressure in the antrum, and the disease was limitied to that area. The roentgen findings described could not be demonstrated. Oddly enough, the very same evening, following operation, there was noticeable improvement in the facial paralysis. At the end of the first week there was no trace of facial paralysis or weakness. At the time of writing the mastoid cavity is healing satisfactorily and I believe the ear will be dry soon. While curetting this cavity in the course of postoperative treatment, I noticed a fairly large dehiscence in the facial ridge, almost at the level of the floor of the external auditory meatus. If the damage to the facial nerve occurred at this point, below the level of the chorda tympani, this would explain the preservation of taste sensation as mentioned

As for the 3 cases in which the cavity never has healed and still produces a purulent discharge, the explanation in 2 cases is simply that the patients did not come to the clinic regularly enough. Granulation tissue had an opportunity to accumulate, blind pockets were formed as a result, and dermatization was incomplete. In

the third case I see no explanation for the failure of the cavity to heal properly. The patient attended the clinic regularly, and the granulations were kept down well; in spite of this, dermatization stopped before the middle ear was healed, and a purulent discharge has been present since. Hearing tests made before and after operation showed an increased loss of hearing following surgical treatment in all cases. One patient had an increase in loss of 2.4 per cent; another, 10.9 per cent, and the last of this group, 24.2 per cent. None of these patients has good serviceable hearing in the ear operated on. I should like to refer to 1 case in particular.

R. T., a 16 year old youth, had had draining of the left ear for so long that it was difficult for him to remember accurately the time of onset, but he stated that he thought it began in 1933. He was seen at this clinic for the first time six years later. About one month after the first visit he was treated by modified radical mastoidectomy. The ear continued to discharge in spite of all conservative measures attempted. I saw him for the first time in January 1943. At that visit he stated that for the past three months he had had attacks of vertigo during which the "room would swirl around." The canal of the left ear was filled with a foul thick purulent discharge. The drum was completely destroyed, and the middle ear was filled with granulations. There was a positive fistula test. A hearing test at that time showed a loss of 14.4 per cent in the diseased ear. Roentgen examination showed a surgical defect but did not reveal any pathologic alteration of the remaining bone. In order to clean out the middle ear completely and to determine the progress of the suspected circumscribed labyrinthitis, I performed the radical mastoidectomy in the manner already outlined. At operation no fistula was identified. In endeavoring to remove the vertical overhang more completely I encroached too much on the region of the oval window, and a twitch of the face was immediately described by the anesthetist. When the patient recovered from the anesthesia, complete left facial paralysis was observed. In two months' time there was no tendency to recover, and response to the faradic current was absent. In the absence of this response it was not considered advisable to delay further uncapping and decompressing the facial nerve. This was done, and at operation the nerve appeared to be intact, with no grafting necessary. It is now eleven months since the nerve was decompressed and the face has shown no improvement. There is still no response to the faradic current. Since the time of the radical procedure the patient has come to the clinic only sporadically, and as a result the cavity is filled with granulations and a purulent discharge persists. The patient is, however, free from vertigo. A hearing test done recently showed that he had a loss of 38.6 per cent in the ear operated on. This represents an increase in loss of 24.2 per cent. It seems safe to assume that since the facial nerve has shown no tendency toward return of function at this time, it will not without further surgical intervention in the nature of grafting. The patient, however, refuses further surgical treatment.

I present the foregoing case chiefly to show the extreme vulnerability of the area on the facial ridge immediately above the oval window. If curettage is attempted in this region, the facial nerve will almost certainly be injured.

Earlier I stated that there were 3 cases in which the cavity was entirely healed except for a small area in the region of the eustachian tube. These patients are quite comfortable and usually the discharge, which is recurrent, is odorless. It is most profuse during an acute infection of the upper respiratory tract. By cleansing their cavities with hydrogen peroxide periodically, they can keep the ears operated on essentially dry. They too showed uniformly a loss of hearing in a comparison of preoperative with postoperative levels. One had a postoperative increase in hearing loss of as much as 10.3 per cent; another, as little as 2.8 per cent, and the third, 6.8 per cent. I am sure that the reason each of these patients is left with a permanently draining eustachian tube is because, in the first place, the middle ear was not opened sufficiently at the time of operation (especially, the hypotympanum was not lowered enough) and, in the second, granulations were allowed to form in the middle ear postoperatively and pocket off the mouth of the tube. In treating cavities from radical mastoidectomies other than my own, I have come to the same conclusions as to the cause of the draining into the eustachian tube. The middle ear must be opened wide, and there must be no bony or soft tissue pocket in the region of the tube. I think this particular factor is much more important than the condition of the nose or the nasopharynx, although that should certainly be kept in mind.

The remaining 4 cases to be considered are those in which the cavity is completely dermatized and dry. In these cases I operated toward the last of my residency, and I think that is one reason why the results are better. In all these patients, the middle ear was opened wide at the time of operation and was kept open postoperatively by the regular removal of granulation tissue from the cavity and the middle ear. At the same time I am convinced that in a certain percentage of cases, no matter how well the operation is performed, and no matter how regular and thorough the postoperative care, the result will be unsatisfactory. That there is wide individual variation in the amount of granulation tissue produced and in the rapidity with which epithelium is generated seems very apparent to me. The 4 patients were seen on an average of three times a week in the clinic for postoperative care. The average time required for the cavities to dermatize fully was twelve and five-tenths weeks. The shortest was eleven weeks and the longest thirteen weeks. In spite of the

fact that in all 4 patients there was a minimum of granulations over the promontory and in the middle ear in general, they all had worse hearing after surgical treatment than before. None of them has good hearing for ordinary conversation in the ear operated on. In 1 patient the percentage loss of hearing prior to operation was 30.4 per cent in the affected ear; after surgical treatment it was 50.4 per cent; in another, it was 25.3 per cent before and 36 per cent after mastoidectomy. The average increase in the loss of hearing when levels before operation are compared with those after operation was 18.9 per cent. Without exception, however, the patients are satisfied with the results even though their hearing is not improved. Actually, in all these patients the increase in hearing loss is of no practical importance, for that increase occurred in a range below the level of serviceable hearing anyway. Furthermore, the patients are rid of a discharge and an offensive odor from the ear. And again, the improvement in their general condition is marked. To be more specific in the discussion of this group, I should like to present a typical case.

R. A. is a man 39 years old. When first seen in the clinic he stated that his right ear had been discharging intermittently for seven years. For the few months previous to his visit to the clinic he had some pain about the ear and around the right side of his head. He also reported bouts of vertigo in which the "room would swing around." He said that the hearing in the ear was poor. The right tympanic membrane was almost completely destroyed. There was considerable granulation tissue in the middle ear, and there was a tract leading into the epitympanum. There was no tenderness over the mastoid process, but the fistula test was positive. Roentgen examination revealed a sclerotic mastoid process. The sigmoid sinus was forward, and although there was some cloudiness in the vicinity of the tympanic antrum, there was no frank evidence of destruction of bone. The remainder of the examination showed no noteworthy pathologic change in the left ear, the nose or the throat. A routine preoperative work-up was done, and no contraindications for surgical procedure were found. Three weeks after his first visit to the clinic I did the radical mastoidectomy. At operation the roentgen observations were borne out to the extent that the entire mastoid process was acellular save for the region of the antrum, and the sinus was far forward. However, contrary to the observations at roentgen examination, there was considerable destruction in the region of the antrum. This was filled with granulations and cholesteatomatous material. The middle ear was similarly involved, and the ossicles were for the most part destroyed. The postoperative course was uneventful, and I saw the patient in the clinic three times a week. There was a great tendency toward the formation of granulations, but these were successfully controlled in the manner outlined previously. It was fourteen weeks before the cavity had completely healed. At the time of writing his hearing loss in the ear operated on is 50.4 per cent; prior to the operation it was 30.4 per cent. In spite of the increase in hearing loss, the patient is well satisfied with the result. He has more energy, eats better, has gained weight and is free from vertigo.

There is no doubt that to achieve a good result with the radical mastoidectomy, long arduous labor is entailed. It is necessary, of course, to open the middle ear well at the time of operation, but I think it is even more important to see the patient at frequent and regular intervals afterward in order to maintain the immediate postoperative result. Once the granulations have invaded the middle ear and have had an opportunity to organize, it is almost impossible to remove them.

It has been the main purpose of this paper to relate the indications and the procedures of the surgical approach to disease of the middle ear and mastoid process as I have learned them from experience as a resident at the New York Eye and Ear Infirmary. In addition I have attempted to review a modest series of cases covering the mastoidectomies that I performed.

# BILATERAL ACOUSTIC NEURITIS

## A REVIEW OF THE LITERATURE AND A REPORT OF A CASE

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The causes of acoustic neuritis discussed in the literature have been varied, each stressed in turn over a period of years. Focal infection from tonsillitis or a dental abscess, diphtheria, meningitis or some other acute infectious disease, vitamin deficiency and the toxic effects of such drugs as quinine, arsenic, the salicylates and possibly the sulfonamide compounds have been designated as causes of acoustic neuritis in cases in which this condition was proved present.

Auditory neuritis was described by Wintermute [1] in 1915 as a disease coming on suddenly which produces tinnitus and deafness when the cochlear branch is affected, vertigo, disturbances of equilibrium, spontaneous nystagmus and vomiting when the vestibular branch suffers and a combination of these symptoms when both branches are involved. He stated that the disease is due to syphilis in the great majority of instances but concedes that alcoholism, drug poisoning from quinine or the salicylates and even toxemia from internal diseases may be the cause. In his description of the disease the shortness of bone conduction is stated to be a constant finding. The tinnitus is abrupt in onset and usually severe; it is constant and not dependent on the pulse or the position of the head. The loss of hearing which follows shows wide variation. In the Weber test the sound lateralizes toward the side of the better ear; the Rinne test shows a ratio of hearing by air conduction to that by bone conduction of 2:1, and the high-pitched tones are poorly heard.

Mackenzie [2] used the galvanic test to distinguish irritative from destructive lesions and concluded that the diagnosis of acoustic neuritis could be made from the results of this test alone. In a later article he [3] reported a case in which eighth nerve neuritis involving both the vestibular and the cochlear branch resulted from a focal infection in the appendix. He stated that unilateral eighth nerve neuritis is due to focal infection in most cases, but that, whether it is unilateral or bilateral, many factors must be considered. In making this differential diagnosis he rules out the type of neuritis following acute infection, the type occurring in the course of chronic infection, especially infection tending toward granulomatous infiltration (syphilis, tuberculosis or leukemia), the toxic neuritis due to poisons taken internally (alcohol, tobacco, arsenic, mercury, carbon monoxide, quinine, salicylates and others) and finally the type of neuritis resulting from absorption of toxins into the general circulation—the source of which may be a chronic focus of pus in some more or less distant part of the body. He warned that the etiologic factor can be determined only after a most exhaustive search according to a definite plan and a systematic method of exclusion.

It was pointed out by Duel [4] that the optic and the auditory nerves are especially susceptible to toxic neuritis, with emphasis on focal infection as the cause. Toxic neuritis of the eighth cranial nerve may occur when other nerves are involved, when the patient has had no previous difficulty with hearing or when the patient has catarrhal otitis or even otosclerosis.

Steegmann [5] described a form of polyneuritis involving both cranial and spinal nerves which he designated by the term "neuronitis." The disease started with an abrupt onset either immediately after or following a period of latency subsequent to an initial illness and was thought to be due to a virus infection. He observed bilateral sixth nerve palsy associated with papilledema and vertigo in a 38 year old woman ten days after she had acute sore throat. There was complete spontaneous recovery in a period of five months. He reported 3 other cases in which cranial nerves alone were involved. In these the neuritis ran a benign, self-limited course.

1. Wintermute, G. P.: Auditory Neuritis, J. A. M. A. **65**:608 (Aug. 14) 1915.

2. Mackenzie, G. W.: A Case of Eighth Nerve Neuritis, with Interesting Galvanic Findings, Laryngoscope **26**:986 (June) 1916.

3. Mackenzie, G. W.: The Report of a Case of Neuritis of the Eighth Nerve Involving Both Branches from a Focal Infection in the Appendix, Ann. Otol., Rhin. & Laryng. **27**:490 (June) 1918.

4. Duel, A. B.: Toxic Neuritis of the Eighth Cranial Nerve, J. A. M. A. **83**:1129 (Oct. 11) 1924.

5. Steegmann, A. T.: Neuronitis of Cranial Nerves, J. Nerv. & Ment. Dis. **88**:316 (Sept.) 1938.

"Neurolabyrinthitis" is a term used by Mackenzie [6] to designate an inflammation of the eighth cranial nerve and the labyrinth. He maintained that the clinical picture of focal infection in neurolabyrinthitis is so definite that the diagnosis in the average case is quite easy for one who will take the time necessary to obtain exact findings. He expressed the view that this type of infection is the most frequent cause of Ménière's syndrome and concluded that focal infection is the most frequent single cause of perceptive deafness.

Hobart and Miller [7] reported an unusual complication of osteomyelitis, observed in 2 patients. In the first osteomyelitis as a focal infection ended in complete nerve deafness and generalized amyloidosis. In the second, a patient aged 16, a slow progressive type of nerve deafness developed which was not improved or arrested by treatment of the osteomyelitis. This patient died from an abscess of the brain.

In an article on neurosyphilis, Alfaro [8] stated that nonsyphilitic neuritis of the eighth cranial nerve is a fairly common condition, though frequently overlooked. Its occurrence as a complication of meningitis, measles, mumps, scarlet fever, influenza, pneumonia and diphtheria should be considered. What the explanation of nerve deafness in a given case may be cannot be deduced without the help of a clinician and a laboratory. The absence of a history of syphilis does not rule out syphilitic involvement of the eighth nerve. Syphilis must be suspected as a possible cause in all cases of sudden nerve deafness in which there has not been a preexisting infectious disease of the type which might produce the neuritis.

Rosenwasser [9] stated that the neuritis resulting from arsenic poisoning is caused by the affinity of the poison for the lipoids of the myelin sheath. He reported a case of neuritis of the auditory nerve with recovery which occurred during the course of intravenous arsenic medication. He pointed out that arsenic is slowly excreted from the body. Only 20 per cent of the arsenic administered intravenously is eliminated in the feces and the urine. The balance is stored in the tissues for a long time and is slowly excreted via the skin. The effects of arsenic poisoning, especially the paralyses, last long after the original portion of the drug has been excreted. If aural symptoms supervene during intravenous therapy with a heavy metal, the medication must be discontinued temporarily.

With the discovery of vitamins there were new explanations for disorders of the nervous system. Experimental work showed that in vitamin B deficiency lactic acid accumulates in various parts of the central nervous system. This localized acidosis explains the opisthotonos observed in a group of experimental pigeons deficient in vitamin $B_1$. Selfridge [10] remarked that it would be evident to any one observing a group of experimental animals deficient in vitamin B complex that they do not respond normally to different types of sound stimuli. He produced progressive degeneration of the eighth nerve in animals by feeding diets deficient in vitamin B.

Lewy [11] called attention to the fact that the basic factor of most, if not all, neuropathies probably is the lack of vitamin $B_1$. Wechsler substituted the term "neuropathy" for "neuritis." The histologic changes found in metabolic, toxic and infectious involvements of nerves are not those expected in an exudative or inflammatory leukocytic infiltration. Instead, they are characterized by cloudy swelling, ballooning of the medullary sheath, coil formation of the axis-cylinder and at a later stage granular disintegration. These changes are observed in experimental deprivation of vitamin $B_1$. The process is one of failure of normal restoration and repair rather than inflammation.

Brandenburg [12] reported a case in which severe bilateral tinnitus and impairment of hearing followed extensive radiation therapy for carcinoma of the uterine cervix. Relief was obtained by daily intravenous administration of thiamine hydrochloride in doses of 15 mg. for a period of nine days. He suggested the use of intravenous therapy with thiamine hydrochloride in one or more daily doses for all neuropathies of cranial nerves.

In recent years another series of drugs has been added to the list of substances which may produce toxic neuritis involving the acoustic

6. Mackenzie, G. W.: Neuritis Acoustic, Neuro-Labyrinthitis, Internat. Clin. **2**:126 (June) 1938.

7. Hobart, M. H., and Miller, D. S.: Unusual Complications (Cutaneous Cancer and Neuritis) of Osteomyelitis, Am. J. Surg. **45**:53 (July) 1939.

8. Alfaro, V. R.: Neurosyphilis from Standpoint of Otologist, M. Ann. District of Columbia **3**:215 (Aug.) 1934.

9. Rosenwasser, H.: Neuritis of the Auditory Nerve Occurring During Intravenous Arsenic Medication: Report of Case with Recovery, Arch. Otolaryng. **15**:284 (Feb.) 1932.

10. Selfridge, G.: Eighth Nerve High Tone Deafness from a Nutritional Standpoint, Ann. Otol., Rhin. & Laryng. **46**:93 (March) 1937.

11. Lewy, F. H.: Neural Mechanism of Hearing: Pathology of Nerve Deafness, Laryngoscope **47**:409 (June) 1937.

12. Brandenburg, K. C.: Relief of Neuritis of Eighth Cranial Nerve with Vitamin $B_1$, Arch. Otolaryng. **31**: 189 (Jan.) 1940.

nerve. Ornsteen and Furst [13] reported a case in which toxic neuritis with a picture similar to that of progressive muscular dystrophy probably resulted from excessive ingestion of sulfanilamide (130 Gm. in thirty-five days). Wigton and Johnson [14] reported 4 cases in which peripheral neuritis resulted from administration of sulfanilyl sulfanilamide. These patients had pain in their calves, disturbances of gait and an absence of the achilles tendon reflex. Bliss and Long [15] showed that large doses of sulfanilamide given to mice produced symptoms of bilateral vestibular dysfunction associated with curious spastic paralyses. Garvin [16] reported a death from a toxic psychosis with convulsions following the administration of sulfamethylthiazole.

In discussing the cerebral symptoms occurring during the treatment of meningococcic meningitis with sulfapyridine, Johnstone and Forgacs [17] suggested that the cerebral symptoms which persisted in spite of intensive drug therapy were due to the toxic effect of the sulfapyridine. Sugar [18] reported a case in which peripheral neuritis with recovery resulted from administration of 50 Gm. of a dextrose-sulfapyridine compound. Long, Haviland, Edwards and Bliss [19] noted that ocular and auditory disturbances are present during the use of sulfanilamide or its derivatives but stated that actual changes in vision or auditory acuity are rare.

In an extensive preliminary experimental report on the injury caused by sulfanilamide and some of its derivatives, Bieter and associates [20] stated that any one of the drugs studied may occasionally produce lesions of nerves. Their conclusions were drawn from experimental work on chickens and a complete review of the available clinical data on peripheral neuritis. In this same report they presented a case of peripheral neuritis involving the acoustic nerve. Briefly, the history was this: Seven weeks after sulfathiazole therapy was begun, the patient suddenly became deaf in her left ear. This was a typical nerve type loss of hearing. There also developed numbness, weakness and later foot drop in her right lower limb. Two weeks after the sulfathiazole therapy had been discontinued, the foot drop and other related symptoms had improved, but the deafness remained almost complete. In 1941 when Bieter and associates reported this case, it was the only published case of acoustic neuritis due to sulfonamide therapy.

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14. Wigton, R. S., and Johnson, S. H: Peripheral Neuritis Following Sulfanilyl Sulfanilamide: Report of Four Cases, J. A. M. A. **111**:1641 (Oct. 29) 1938.

15. Bliss, E. A., and Long, P. A.: Clinical and Experimental Use of Sulphanilamide, Sulphapyridine, and Allied Compounds, New York, The Macmillan Company, 1939.

16. Garvin, C. F.: Peripheral Neuropathy and Toxic Psychosis with Convulsions Due to Sulfamethylthiazol: Case, Am. J. M. Sc. **200**:362 (Sept.) 1940.

17. Johnstone, D. F., and Forgacs, P.: Cerebral Symptoms Occurring During Sulfapyridine Treatment of Meningococcal Meningitis, Brit. M. J. **1**:772 (May 24) 1941.

18. Sugar, S. J.: Peripheral Neuritis Following Administration of Glucose Sulfapyridine Compound, New England J. Med. **226**:1021 (June 25) 1942.

19. Long, P. H.; Haviland, J. W.; Edwards, L. B., and Bliss, E. A.: The Toxic Manifestations of Sulfanilamide and Its Derivatives, J. A. M. A. **115**:364 (Aug. 31) 1940.

20. Bieter, R.; Baker, A. B.; Beaton, J. G.; Shaffer, J. M.; Seery, T. M., and Orr, B. A.: Nervous Injury Produced by Sulfanilamide, J. A. M. A. **116**:2231 (May 17) 1941.

### REPORT OF CASE

A white man aged 23 was admitted to the medical service of a station hospital at 3 p. m., Oct. 27, 1941, with the diagnosis of acute follicular tonsillitis.

The treatment given was irrigation of the throat with hot saline solution every two hours while awake, 5 drops of 1 per cent ephedrine in isotonic solution of sodium chloride in each nostril four times a day and 15 grains (0.97 Gm.) of sulfanilamide together with 10 grains (0.65 Gm.) of sodium bicarbonate every four hours while awake. The sulfanilamide was discontinued on November 1. At noon on October 28 the patient was given acetylsalicylic acid, 10 grains. The following day the patient complained of an earache on the right side and was given 2 capsules, each containing 5 grains of acetylsalicylic acid, 2 grains (0.13 Gm.) of acetophenetidin and ½ grain (0.03 Gm.) of caffeine. On November 3 the patient showed marked improvement of the tonsillitis but complained of deafness in the right ear. He was referred to the eye, ear, nose and throat clinic for consultation. There he gave a history of earache of short duration on the right side, occurring twice while he was in the hospital, and of recent sudden onset of poor hearing with the right ear.

On examination the tympanic membranes were intact, with no inflammation. The nose showed moderate deviation of the septum toward the right, some mucoid discharge in the right middle meatus and adequate air space in the left nostril. The tonsils were of the small cryptic type, with little residual inflammation. The tuning fork tests gave results as follows: No fork was heard with the right ear; in the Weber test the sound was lateralized to the left; in the Rinne test air conduction was greater than bone conduction. Hearing tested with the spoken voice was 2/20 on the right and 20/20 on the left. A tentative diagnosis of defective hearing in the right ear, perceptive type, acute, cause undetermined, was made.

The recommendation was: Discontinue all medication and return to the eye, ear, nose and throat clinic November 5 for observation.

On November 4 the patient was given an emergency furlough because of a death in his immediate family. He was instructed to come to the clinic after his return.

The diagnosis at discharge was: (1) bilateral tonsillitis, acute, follicular, cause undetermined; (2) defective hearing in the right ear, acute, perceptive type, secondary to (1); hearing—2/20 right, 20/20 left.

The patient was readmitted to the hospital November 15. His chief complaints at this time were that he was unable to hear anything with the right ear and had a roaring sensation in the left ear, with a "pulsing" which made it difficult to understand spoken words, and a pressure sensation over both eyes, which became worse when going from a lighted to a dark room.

The previous occupations had been those of farmer and concrete worker. As to habits, the patient stated that he smoked 25 to 30 cigarets daily but was not addicted to the use of any drug or alcohol.

The father, mother, six brothers and three sisters were living and well. There was no family history of syphilis, epilepsy, diabetes, insanity or deafness.

The patient during childhood had had pertussis, chickenpox, measles and diphtheria; he had pneumonia at the age of 20 and no sore throats until this October. He said that he had never had a venereal disease. He finished the eighth grade and then quit school to help his father.

He said that he was well until Oct. 25, 1941. At that time he was placed on flood detail and drove a truck down close to the river's edge. His truck "got stuck," and in trying to get the truck out of the mud he perspired freely. The weather suddenly became colder. He remained at work about two hours longer and went back to his barracks with a throbbing right earache, a sore throat and some stiffness in his neck muscles. He reported for sick call the next day and was sent to the hospital. In the hospital he could not hear with his right ear but it did not ache. He was unable to fix a time for the onset of the poor hearing. The left ear was normal at the time. He denied any history of dizziness, disturbances in gait (staggering), difficulty in speech or other evidence of vestibular or cerebral involvement occurring while he was on his emergency furlough.

He was a well developed white man aged 23, 67 inches in height and 160 pounds (72.6 Kg.) in weight. The head and neck were normal. The drumheads were intact, with no evidence of inflammation. The nasal septum was thickened and showed moderate deviation toward the right; there was adequate air space and there was no purulent discharge in either nostril. All sinuses transilluminated normally. The tonsils were small, recessed, fibrotic, with no inflammation. The heart was normal; there were no murmurs; the heart tones were normal. The blood pressure was 116 systolic and 70 diastolic.

Dental consultation revealed no foci of infection, and a complete set of roentgenograms of the mouth were normal.

Vision was 20/20 bilaterally. The fundi were normal, with no evidence of increased intracranial pressure.

The genitourinary tract showed no foci of infection.

The neurologic consultant reported: "This case appears to be one in which the eighth (auditory) nerve alone is involved. Specifically, the cochlear branch seems to be more involved because of the associated tinnitus. I suggest the making of stereoscopic roentgenograms of the skull to rule out trauma with fracture in the region of the internal auditory meatus. Spinal puncture showed normal clear fluid under normal pressure; the Wassermann reaction, the colloidal gold curve and the protein content are normal.

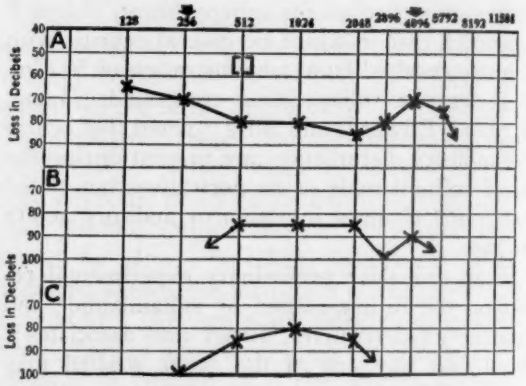
"Opinion: If stereoscopic roentgenograms of the skull reveal no fracture, the patient has auditory neuritis, cause undetermined."

Roentgen examination of the sinuses showed no pathologic changes. Stereoscopic roentgenograms of the skull and roentgenograms of the internal auditory meatuses made December 29 were normal.

Repeated urinalyses and studies of the blood, including Wassermann and Kahn tests, gave normal results.

On November 22 the patient did not hear a loud spoken voice with the right ear; the hearing in the left ear was questionably 20/20 for a low conversational voice. The Kobrac vestibular test with cold water showed the horizontal and vertical semicircular canals active bilaterally. A course of treatment with vasodilators was begun and carried on for a period of ten days (erythrol tetranitrate, 1 grain [0.06 Gm.] four times a day, alternating with sodium nitrite, 0.1 Gm. injected intravenously twice a day).

December 1 the only change noted following the use of the vasodilators was possibly less roaring tinnitus in the left ear. A series of eight therapeutic fevers induced with foreign protein (a vaccine made from the typhoid bacillus and the paratyphoid A and B bacilli intravenously injected) was begun, alternating every other day with sweats induced with a pilocarpine salt. December 26 there was still no improvement of hearing in the right ear. Hearing in the left ear decreased to about 10/20 for a low conversational voice. The loss seemed to have a daily variation, being worse in the morning.




*A*, first audiogram, taken when an audiometer was issued to the eye, ear, nose and throat clinic, March 7, 1942. The brackets indicate the only tone heard by bone conduction on the left side. No tones were heard by either air or bone conduction with the right ear. *B*, audiogram taken March 30. It shows still more loss of hearing. No tones were heard by bone conduction with either ear. *C*, final audiogram, taken April 15, shows almost complete loss of hearing in both ears. No tones were heard by bone conduction with either ear.

December 31 a complete recheck of the ears, the nose and the throat for possibilities showed no other abnormalities. The Kobrac labyrinthine test still showed a live right labyrinth. The eustachian tubes were catheterized; both were patent. The Gellé test showed the drumheads movable, with no fixation of the stapes. The patient was then receiving 15 drops of a saturated solution of potassium iodide in water by mouth three times a day with meals.

Jan. 26, 1942 the administration of the iodide was discontinued. The patient was then receiving vitamin B complex four times a day.

February 15 there was no change in the condition of the ears. Hearing with the left ear was still approximately 10/20. The patient had mild acute rhinitis. He was given 1 per cent ephedrine in isotonic solution of sodium chloride in the form of nose drops four times a day.

March 7 an audiometer was obtained by the eye, ear, nose and throat clinic. The first audiogram (*A* in figure) showed complete loss of hearing by air and bone conduction for the right ear, with severe (65 to 85 decibel) air conduction loss for the left ear. The only tone heard by bone conduction with the left ear was 512.

March 8 the case was reviewed completely with a consultant. Medical, genitourinary and dental consultations again revealed no foci of infection. The Kobrac vestibular test (cold water) elicited normal reactions for the left labyrinth, with the reaction on the right side sluggish but still indicative of a live labyrinth. Tuning forks were not heard by the right ear. The 256 fork was heard only slightly by air conduction with the left ear. Tonsillectomy was advised as removing a possible focus of infection.

March 10 tonsillectomy was done, small fibrotic tonsils being removed.

March 22 the throat was healed, with no improvement in hearing and no stoppage of the progress of this disease.

April 15 a complete review of this case showed the same physical findings for the ear, the nose and the throat except that the tonsils had been removed. The eustachian tubes were normal on catheterization; the vestibular tests showed sluggish reactions in the right ear but normal reactions for both the horizontal and the vertical semicircular canal in the left ear. The audiogram (*B* in figure) showed marked loss of hearing. Hearing was less than 1/20 for a loud spoken voice. The patient studied lip reading and became fairly well adjusted mentally. No therapy is prescribed at the present time.

The patient was last seen August 28. His only complaint was an occasional feeling of fulness in his ears. Examination of the ears, the nose and the throat gave negative results except for complete bilateral loss of hearing.

The diagnosis was bilateral acoustic neuritis, severe, chronic, progressive, cause undetermined.

## COMMENT

Bilateral progressive acoustic neuritis in a 23 year old soldier ended in complete deafness in a period of months. Spinal puncture ruled out syphilis. The therapy included administration of vasodilators, foreign protein to produce fevers, pilocarpine to induce sweats, iodides and vitamins and complete elimination of possible foci of infection. These measures did not stop the progress of the disease. A definite statement cannot be made concerning the cause of the loss of hearing in this case.

# REDUCED ATMOSPHERIC PRESSURE AS A FORM OF TREATMENT FOR PARANASAL SINUSITIS

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The use of the low pressure chamber in relieving sinusitis was first reported by Andrews, Roth and Ivy in 1940.[1] They studied the effects of reduced atmospheric pressure in 16 cases of advanced sinus disease and noted subjective relief of symptoms in 14 cases. The patients reported a marked increase in drainage, with diminution of pain, pressure and nasal congestion. In that preliminary report a simple nontraumatic method of promoting drainage and aeration of sinuses was presented and its possible application as a practical therapeutic measure in cases of sinus disease was suggested. The principle was first used by Behnke [2] in 1932; he used slow compression followed by rapid decompression in the high pressure chamber.

In the past two years the decompression method has been used by us in the treatment of a series of 125 patients with subacute and chronic sinusitis, and the effects on the progress of their sinus disease have been studied.

## TYPE OF PATIENTS TREATED

The patients treated had all been proved to have sinus disease and had definite symptoms attributable directly to their sinusitis. The majority of them had been referred to us for treatment after the usual therapeutic measures had failed. Thirty-nine (31.2 per cent) had submitted to previous surgical intervention, 40 (32.0 per cent) had had their sinuses lavaged after cannulation or puncture, 13 (10.4 per cent) had been treated by displacement therapy and 20 (16.0 per cent) had used siphonage in attempts to control their disease. Six had received injections of vaccine, 5 had taken diathermy treatments and 2 had been treated by nasal packs. Sixty-three of the patients used some type of nasal drops or spray in attempting to alleviate their symptoms.

No patients with acute sinusitis have been included in the series. The average duration of the sinus disease in the patients studied was nine and five-tenths years. It is evident that this series does not represent the typical clinical group but is a series of patients with long-standing refractory infection.

## METHOD OF TREATMENT

*The Decompression Chamber.*—Treatments were administered in a large decompression chamber of the type currently used for studies of aviation medicine. The chamber consists of a small sealed room with outlets to rotary vacuum pumps so that the chamber can be rapidly evacuated to various levels of atmospheric pressure. The first 60 patients of this series were treated in a chamber that accommodated 2 patients at a time, but a much larger chamber has now been constructed which permits as many as 10 or 12 patients to be treated simultaneously. Observation windows and a two way speaker system permit constant oversight of the patients and conversation with them.

*The Method of Decompression.*—A standardized method of treatment was developed and used in all cases. The pressure was rapidly reduced to 522.6 mm. of mercury, the equivalent of ascent to an altitude of 10,000 feet. The rate of the "ascent" was 5,000 feet per minute. On reaching the pressure at 10,000 feet recompression ("descent") was begun, but at the much slower rate of approximately 700 feet per minute.

The rate of "descent" or recompression was determined by the tolerance of the patients. During recompression or "descent" air must pass through the eustachian tube into the middle ear. The anatomy of the eustachian orifice and tube is such that rapid passage of air into the tube causes it to collapse in a valvelike manner. If recompression is continued after closure of the eustachian tube, the differences in pressure on the two sides of the tympanic membrane cause it to retract, and the sharp pain of aero-otitis media results.[3] This unpleasant situation is the exact parallel of the aero-otitis media occurring on rapid descent in an airplane.

The patients were thus treated by rapid decompression to the pressure at 10,000 feet and then by slow recompression to the pressure at 5,000 to 6,000 feet. Rapid "ascent" to 10,000 feet was alternated with slow "descent" to 5,000 to 6,000 feet for a period of forty minutes, and then slow "descent" to ground level completed the treatment. An entire treatment required approximately one hour. The number of "ascents" included in a single treatment varied from four to six, depending on the patients' ability to "descend" at a greater or less rate without aural symptoms. The rate of "descent" was carefully controlled by asking the patients if they felt any pain in their ears.

From the Department of Physiology, Northwestern University Medical School.

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1. Andrews, A. H.; Roth, L. W., and Ivy, A. C.: On the Use of Reduced Atmospheric Pressure in the Treatment of Paranasal Sinusitis: A Preliminary Report, Quart. Bull., Northwestern Univ. M. School **15:** 46, 1941.

2. Behnke, A. R., Jr.: Compressed Air Therapy Relative to the Sinuses and the Ear, U. S. Nav. M. Bull. **30:**177, 1932.

3. Armstrong, H. G.: Principles and Practice of Aviation Medicine, Baltimore, Williams & Wilkins Company, 1939.

*Records.*—All patients were required to have confirmed evidence of sinus disease before any decompression therapy was begun. Rhinologic examinations were routine, and roentgenologic examinations were required in all cases in which sinus disease was not obvious on clinical examination. Detailed histories of symptoms were taken before each treatment, and the trends of subjective results were studied. Patients were receiving no other form of sinus therapy during decompression studies.

Information as to subjective results was obtained by routine questioning about the presence of the symptoms complained of and the degree of relief obtained. In addition, questionnaires were sent to all patients at an interval of two months to a year after termination of treatments and the responses noted. It was felt that answers to questionnaires sent after therapy had ceased might be more honest and unbiased. In every case in which the responses obtained during treatments did not correspond to those obtained by questionnaire, the most unfavorable response was used in computing the final results of therapy. All patients were asked if they wished to return for further treatments at a future date, and their response to this query was given consideration in evaluating the subjective response.

TABLE 1.—*Subjective Results*

| Results | Patients | | |
|---|---|---|---|
| | Number | Per Cent | |
| No improvement | 13 | 10.5 | |
| Fair | 26 | 21.0 | 89.5 |
| Good | 43 | 34.6 | |
| Excellent | 42 | 33.9 | |
| Total | 124 | | |

## SUBJECTIVE RESULTS

Patients were treated twice weekly as a rule. Occasional ones were treated from once to four times weekly. Altogether, 2,259 treatments were given to the group—an average of 18.1 treatments per patient.

The efficacy of decompression therapy in relieving the symptoms of sinus disease is evidenced in the results summarized in tables 1 and 2. No general summary can give the true picture, since individual responses to therapy varied widely, but it is felt that individual case histories tend to give only the optimistic side of clinical results, and for this reason case histories have been omitted from this report.

Some patients were dramatically relieved of symptoms after only one or two treatments, while others required a larger number of treatments before symptoms gradually subsided. Paradoxically, the number of treatments necessary to produce definite relief had no apparent relation to chronicity of disease; in fact, several of the most dramatic results were obtained in patients complaining of sinus disease of ten to twenty years' duration, while a few with disease of only a few years' duration required repeated treatments before relief was obtained.

The permanence of results was extremely variable. In some patients followed for over two years after stopping treatments, no return of symptoms was noted; in others symptoms returned only with occurrence of an acute infection of the upper respiratory tract, and could be easily controlled by a few treatments at that time; in a larger group relief of symptoms seemed dependent on regular treatment. Before this question can be settled definitely, a lengthy follow-up study over a period of several years will be necessary. It may be said, however, that patients undergoing treatment in the earlier stages of their disease, before severe pathologic changes have occurred, have much better prospects of permanent relief. Our series of patients with early or subacute disease has been too small to give any definite figures at this time.

TABLE 2.—*Breakdown of Subjective Results by Symptoms*

| | Results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No Improvement | | Fair | | Good | | Excellent | | | |
| | Per Cent | Patients | Per Cent | Patients | Per Cent | Patients | Per Cent | Patients | Per Cent Improved | Total Patients |
| Headache | 10.6 | 10 | 17.0 | 16 | 37.3 | 35 | 35.1 | 33 | 89.4 | 94 |
| Nasal congestion | 3.8 | 2 | 25.0 | 13 | 46.2 | 24 | 25.0 | 13 | 96.2 | 52 |
| Profuse drainage | 36.4 | 16 | 34.1 | 15 | 18.2 | 8 | 11.3 | 5 | 63.6 | 44 |
| Blurred vision | 23.8 | 5 | 28.6 | 6 | 14.3 | 3 | 33.3 | 7 | 76.2 | 21 |
| Cough | 21.0 | 4 | 36.8 | 7 | 31.6 | 6 | 10.5 | 2 | 78.9 | 19 |
| Asthenia | 10.7 | 2 | 28.6 | 8 | 32.1 | 9 | 28.6 | 8 | 89.3 | 28 |
| Otitis | 40.0 | 6 | 13.3 | 2 | 20.0 | 3 | 26.7 | 4 | 60.0 | 15 |
| Pharyngitis | 16.7 | 3 | 33.3 | 6 | 38.9 | 7 | 11.1 | 2 | 83.3 | 18 |
| Anosmia | 23.1 | 3 | 15.4 | 2 | 30.8 | 4 | 30.8 | 4 | 77.0 | 13 |
| Deafness | 66.7 | 6 | 11.1 | 1 | 11.1 | 1 | 11.1 | 1 | 33.3 | 9 |
| Recurrent rhinitis | 8.3 | 1 | 25.0 | 3 | 50.0 | 6 | 16.7 | 2 | 91.7 | 12 |
| Swelling of face | 22.2 | 2 | 22.2 | 2 | 11.1 | 1 | 44.4 | 4 | 77.7 | 9 |

The incidence of various symptoms in our series (table 2) is rather typical of any group of patients with chronic sinusitis.[4] Headache or pain in the head was the predominant symptom, occurring in 75.2 per cent of the patients, and

4. Thorburn, I. B., and Ratazzi, L. L.: Maxillary Sinusitis: A Statistical Investigation, J. Laryng. & Otol. **50**:185 (March) 1935.

improvement was noted in 89.4 per cent. It was observed that patients characteristically reported a marked increase in drainage of the sinuses followed by relief from pain in the head. The association of drainage with relief from pain was consistent, and patients learned to become alarmed if drainage slowed or stopped.

The nasal congestion and pressure seen in 41.6 per cent of the cases was relieved in all but 2. It seems that much of the engorgement of nasal erectile tissues was a direct result of irritation by the purulent discharge slowly draining from the infected sinuses. As drainage was enhanced and the discharge became less purulent, the nasal tissues returned to normal turgor, and congestion ceased. Many patients noted that they could breathe through their nostrils for the first time in many years. The associated anosmia complained of by 13 patients was relieved in 10 (77.0 per cent).

Improvement in subjective deafness was noted in only 33.3 per cent of the 9 patients complaining of this symptom. It is possible that the loss of hearing in these patients represented well developed deafness and that sinus therapy could not be expected to influence it. They all gave histories of very chronic sinus disease and repeated attacks of otitis media.

The influence of decompression therapy on the occurrence of acute rhinitis in patients with sinusitis is well illustrated by the prevention of recurrent rhinitis in nearly all patients complaining of repeated acute infections. Many reported that acute infections of the upper respiratory tract were much better tolerated after treatment than before decompression therapy. One patient formerly had temperatures of 102 F. and was incapacitated for from five to seven days with each attack of acute rhinitis, but after a series of decompression treatments no more fever developed and she never lost a day from her work because of an infection of the upper respiratory tract.

In no cases yet studied have the symptoms been aggravated or increased as a result of decompression therapy. Increased drainage occurs commonly in cases of chronic obstructive sinusitis, but drainage gradually subsides as the infection is brought under control. Some patients may complain of cough and even mild pharyngitis after the first few treatments, but these symptoms disappear as the drainage decreases.

### OBJECTIVE RESULTS

*Roentgenologic Examination.*—Evaluation of any new therapeutic procedure in cases of sinus disease is beset with many difficulties. There is no single objective criterion by which one may measure the progress of sinusitis. Roentgenologic examination is of definite value, but normal-appearing sinuses are not uncommon in cases of early and nonsuppurative sinusitis.[5] Thorburn and Ratazzi [4] estimated that in 13 per cent of their series of 159 cases of chronic maxillary sinusitis there was no roentgen evidence of disease. It is evident that measuring improvement of sinusitis by roentgen study would entail a much greater error than the 13 per cent occurring with simple diagnosis. Roentgen studies are of special value in the diagnosis of acute suppurative conditions and long-standing chronic infections with resultant metaplasia and fibrosis. Cases of acute suppurative sinusitis have not been included in this study, and it is doubtful whether severe pathologic changes occurring in old chronic sinus disease will be greatly altered by any therapeutic measure.

With these limitations in mind, routine roentgenologic study of the paranasal sinuses seems of little value in studying progress during treatment. The use of radio-opaque oils does enhance the value of a roentgen study. The functional ability of the sinuses to fill and drain adequately in nonallergic conditions can be measured, and these factors are excellent yardsticks of progress in therapy. The Proetz displacement method has been well established and is a simple nontraumatic method for instilling radio-opaque oils into the sinuses.[6] By this method it is possible to measure pathologic changes in the mucosal lining, the patency of the ostiums of the sinuses and the ability of the sinuses to drain adequately.[7] Faulty drainage is a factor of prime importance in sinus disease, and its study is appropriate to any therapeutic evaluation.

A group of 29 patients were carefully studied before, during and after a series of decompression treatments by means of roentgenograms made with instillations of radio-opaque oil. A brominated olive oil [8] was introduced by the displacement technic.[7] A roentgenogram was taken immediately after instillation of the oil, and the ability of the oil to drain was studied by a second roentgenogram made seventy-two hours

5. Skillern, S. R.: Clinical Versus X-Ray Diagnosis of Sinusitis, Ann. Otol., Rhin. & Laryng. **41**:1096 (Dec.) 1932.

6. Proetz, A. W.: An Evaluation of the Displacement Method with a Review of the Literature, Ann. Otol., Rhin. & Laryng. **46**:699 (Sept.) 1937.

7. Proetz, A. W.: The Displacement Method of Sinus Diagnosis and Treatment, St. Louis, Annals Publishing Company, 1939.

8. The brominated olive oil used was brominol light, manufactured by Abbott Laboratories. This oil contains about 33 per cent bromine. It is stable; it is distinctly but not severely irritant and does not cause iodism; it is easily instilled and drained off. It has proved very satisfactory in our study of the sinuses.

later. According to Proetz,[7] the oil will have completely drained from normal sinuses within seventy-two hours. Diseased sinuses show retention of the oil in seventy-two hour roentgen studies.

In each case in which filling of the sinuses did not occur on the first trial, a second and a third trial were made before it was concluded that the ostiums of the sinuses were so obstructed as not to admit the oil. The results of this study are summarized in table 3.[9]

TABLE 3.—*Objective Results—Roentgen Studies with Radio-Opaque Oil*

| Results | Patients | | |
|---|---|---|---|
| | Number | Per Cent | |
| No improvement | 12 | 41.4 | |
| Fair | 11 | 37.9 | |
| Good | 4 | 13.8 | 58.6 |
| Excellent | 2 | 6.9 | |
| Total | 29 | | |

*Rhinologic Examination.*—The use of the results of a careful rhinologic examination as criteria of response to therapy is well established.[5] This method, however, is also far from infallible. All rhinologists are familiar with the normal-appearing sinuses which reveal marked infection when explored surgically.

In a group of 42 patients careful rhinologic examinations were made before, during and after a series of decompression treatments. Each examination included careful inspection of the nasal passages and pharynx by direct visualization. The nasopharyngoscope was used to study the more intimate details of the nasal meatuses, accessible ostiums of sinuses and the nasopharynx. Transillumination was a part of every examination. The results of this study are summarized in table 4.

TABLE 4.—*Objective Results—Rhinologic Examinations*

| Results | Patients | | |
|---|---|---|---|
| | Number | Per Cent | |
| No improvement | 12 | 28.6 | |
| Fair | 17 | 40.5 | |
| Good | 12 | 28.6 | 71.4 |
| Excellent | 1 | 2.3 | |
| Total | 42 | | |

*Audiometric Examinations.*—The possibility that decompression treatments might tend to increase the incidence of middle ear infections and deafness must be carefully considered. It is theoretically possible that "descent" or recompression might force mucus and pus into the eustachian tubes and cause otitis media and progression of the deafness so often associated with chronic sinusitis.

Audiometric tests were performed repeatedly on a group of 31 patients. The Western Electric 2-A audiometer was used. The effects of decompression therapy on auditory acuity are summarized in table 5.

TABLE 5.—*Effects on Hearing—Audiometric Examinations*

| Results | Patients | | Treatments |
|---|---|---|---|
| | Number | Per Cent | |
| Worse | 1 | 3.3 | 24.0 |
| No change | 14 | 45.1 | 25.0 |
| Slight improvement | 6 | 19.4 | 28.5 |
| Good improvement | 4 | 12.9 51.7 | 32.0 |
| Excellent improvement | 6 | 19.4 | 48.6 |
| Total | 31 | | |

Acoustic range was measured in a group of 15 patients. The measurements were made with a special audiometer constructed for determining acoustic range.[10] The results are summarized in table 6.

TABLE 6.—*Effects on Hearing—Examinations of Acoustic Range*

| Results | Patients | | Average Range, Vibrations per Second |
|---|---|---|---|
| | Number | Per Cent | |
| Impaired | 2 | 13.3 | Before 30.5-14,000<br>After 37.0-13,600 |
| Unchanged | 4 | 26.7 | Before 25.1-18,500<br>After 25.6-18,750 |
| Improved | 9 | 60.0 | Before 36.2-14,130<br>After 29.1-16,720 |
| Total | 15 | | |

*Complications.*—The incidence of complicating aero-otitis media [3] in our series was remarkably low when one considers that all of the patients treated had infections of the upper respiratory tract and that many had histories of old middle ear infections. A series of 1,472 treatments produced aero-otitis media only ten times. In all the cases except 1 the condition subsided promptly, with no sequelae.

The single case in which infection complicated the simple aero-otitis was instructive. Typical aero-otitis media developed with some serosanguinous exudation in the middle ear and pain. The patient went to an otologist not familiar with the causes or the significance of aero-otitis, and the eustachian tube was catheterized and subjected to vigorous insufflation several times. The

9. Dr. A. F. Galloway, of the department of radiology of Northwestern Medical School, interpreted the roentgenograms for this study.

10. This audiometer was custom built by the Hewlett-Packard Company, Palo Alto, Calif., for Dr. R. H. Seashore. It is a resistance-tuned oscillator giving pure tones from 20 to 22,000 cycles per second with standard volume control.

resultant infection of the middle ear followed a prolonged course. In all other cases (6) conservative management, with an anesthetic agent being applied to the tympanum and a vasoconstrictor spray to the nasal passages, resulted in prompt uncomplicated subsidence of symptoms. It must be emphasized that aero-otitis media is due to physical trauma to the tissues of the middle ear and that the exudation is sterile and will usually remain so if no energetic measures are undertaken once exudation has occurred.

TABLE 7.—*General Data*

| | |
|---|---|
| 1. Total number of patients | 125 |
| 2. Total number of treatments | 2,250 |
| 3. Average number of treatments | 18.1 |
| 4. Roentgenograms | 136 |
| 5. Rhinologic examinations | 133 |
| 6. Audiometric tests | 161 |
| 7. Average duration of disease | 9.5 years |
| 8. Complications—aero-otitis | 7 patients (10 times) |

## COMMENT

*Rationale of Decompression Therapy.*—The aims of therapy for sinusitis are to remove the infectious process and to reestablish normal conditions both physiologically and histologically. That simple nontraumatic drainage and aeration are the best means of attaining these ends is well supported by Proetz,[11] who said, "The ideal treatment is one which will supply the required ventilation and drainage with the least possible damage to the physiologic processes of the nose." Bowen-Davis[12] supports this attitude in that he stated "it is a well established fact that an infected antrum may be cured by drainage, and it follows that by providing free drainage we are doing what Nature has already been doing fairly efficiently."

Of the methods now popular, few approach these criteria for ideal treatment. Trauma to the delicate mucosal surfaces has only recently been emphasized as an undesirable element in rhinologic therapy.[13]

The limitations of lavage either by puncture or by cannulation are well known. Puncture of the sinus wall produces definite trauma and may easily disrupt normal physiologic processes combating infection. Cannulation entails irritation of the mucosa at the ostiums of the sinuses with resultant inflammation.[14] The ethmoid, sphenoid and frontal sinuses are generally inaccessible for lavage, although some exceptions must be made.[15] Lavage is definitely a valuable adjunct to sinus therapy, but is not the final answer to demands for nontraumatic conservative therapy.

Surgical intervention is definitely indicated in certain selected cases in any series, but that it is not a panacea is evident in our series with 31.2 per cent in which previous surgical treatment had left the patient still complaining of sinus disease.

Diathermy, roentgen rays and vaccines are of some aid but fail to promote adequate drainage or to remove infection in most cases.

Packs saturated with mild protein silver and placed in the nasal passages produce secretion and local inflammatory reaction, but the value of this reaction in promoting drainage and healing in the obstructed or infected sinus is problematic.

The displacement method, first introduced by Proetz,[16] for diluting the sinus contents and flushing the exudate from the infected cavities has done much to alter sinus therapy. When used properly, it produces little trauma and has many points of merit. When used carefully and with mild nontraumatic solution, it represents a distinct advance in sinus therapy toward the ideal.[6]

The rapid reduction of atmospheric pressure in the decompression chamber results in mild "suction" through the sinus ostiums (figure). If the ostiums are not obstructed, air passes out into the nasal passages and the pressures are rapidly equalized (fig., *c*). If, however, the ostiums are blocked as in sinus disease, the pressure is not rapidly equalized, but there is produced a firm gentle pressure of expanding air which forces the obstructing mass out of the sinus into the nasal passage (fig., *d*).

Thick mucopurulent exudates that drain slowly through the sinus ostiums are hastened by the gentle "suction." If the obstruction, e. g., a polyp or a hypertrophied mucosal fold, is

11. Proetz, A. W.: Applied Physiology of the Nose and the Accessory Nasal Sinuses, Am. J. Surg. **42**:190 (Nov.) 1938.

12. Bowen-Davis, A.: The Paranasal Sinuses in Children, Proc. Roy. Soc. Med. **31**:1411 (Oct.) 1938.

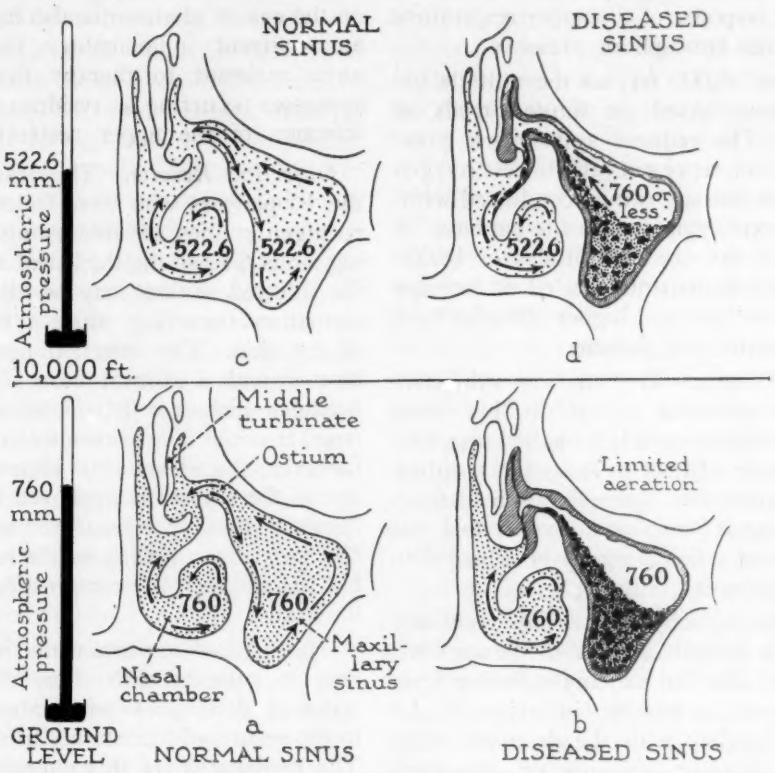
13. (*a*) Hilding, A.: The Physiology of Drainage of Nasal Mucus: II. Cilia and Mucin in the Mechanism of Defense of Nasal Mucus; a Motion Picture Demonstration, Ann. Otol., Rhin. & Laryng. **41**:52 (Jan.) 1932; (*b*) The Physiology of Drainage of Nasal Mucus: III. Experimental Work on the Accessory Sinuses, Am. J. Physiol. **100**:664 (May) 1932. (*c*) Fenton, R. A.: Recent Discoveries in the Pathology of the Nasal and Aural Mucosa, Canad. M. A. J. **32**:147 (Feb.) 1935. (*d*) Proetz, A. W.: Essays on the Applied Physiology of the Nose, St. Louis, Annals Publishing Company, 1941.

14. Hoople, G. D.: Non-Surgical Treatment of Diseases of the Nose and Pharynx, Ann. Otol., Rhin. & Laryng. **48**:73 (March) 1939.

15. Van Alyea, O. E.: Nasal Sinuses: An Anatomic and Clinical Consideration, Baltimore, Williams & Wilkins Company, 1942.

16. Proetz, A. W.: A New Procedure in Sinus Diagnosis, Tr. Am. Laryng. A., 1926, p. 252.

impacted in an ostium, the "suction" will be unsuccessful and equalization will not occur. Thus the drainage mechanism is gentle and does not develop any damaging or crushing force, and trauma to the ostial mucosa is avoided. The advantages of such nontraumatic drainage are obvious; if drainage is possible by conservative measures all trauma is avoided, but if the obstruction is of such a nature that surgical intervention is necessary, no damage has been done




Diagrams showing pressure in a normal and in a diseased sinus at different altitudes.

to the delicate mucosa by attempting drainage by decompression.

The removal of obstruction by altering the density of the air in the sinuses and nasal chambers also has the advantage of promoting increased aeration of these cavities. Aeration of the obstructed sinus seems to be a definite factor in successful therapy.

This simple principle was first described by Braune and Clasen [17] in their classic experiments on sinus pressures. Normal inspiration produces a slight fall in atmospheric pressure in the nasal passages and a slight "suction" through the sinus ostiums as sinus pressure rapidly equalizes. It has been demonstrated many times that sinus disease produces ostial obstruction and that the "suction" is equalized only slowly or not at all.[18]

The purpose of decompression therapy is merely to increase the "suction" to a degree that will enhance the normal physiologic factors producing drainage and aeration of the sinuses without interfering with the highly important mechanisms of ciliary activity and mucosal resistance.

Andrews, Roth and Ivy [1] suggested the possibility that "ascent" also caused vasoconstric-

17. Braune, W., and Clasen, F. E.: Die Nebenhöhlen der menschlichen Nase in ihrer Bedeutung für den Mechanismus des Riechens, Ztschr. f. Anat. u. Entwcklngsgesch. **2**:1, 1876.

18. Proetz, A. W.: Some Intimate Studies of Nasal Function: Their Bearing on Diagnosis and Treatment, Ann. Otol., Rhin. & Laryng. **41**:125 (March) 1932. McMurray, J.: The Intra-Antral Air Pressure Incident to the Respiratory Excursion and Its Effect on Antral Drainage, Arch. Otolaryng. **14**:581 (Nov.) 1931. Hunter, R. J.: Study of Physics of the Antrum, Laryngoscope **42**:163 (March) 1932. Schmücker, K.: Die manometrische Messung des Luftaustausches in der Kieferhöhle und ihre praktische Bedeutung, Ztschr. f. Hals-, Nasen- u. Ohrenh. **30**:638, 1932. O'Malley, J. F.: Ventilation of the Nose and Accessory Sinuses: Oscillographic Method of Investigation, J. Laryng. & Otol. **48**:309 (May) 1933; Ventilation of the Nose and Accessory Sinuses: Oscillographic Method of Investigation, ibid. **50**:389 (June) 1935. Carcò, P.: Sulla partecipazione del seno frontale dell'uomo alle módificazioni delle meccinica respiratoria, Oto-rino-laring. ital. **5**:110 (March) 1935. Judd, D. K.: Air Pressures in the Nose and Maxillary Sinuses Under Normal Conditions and in Disease, Ann. Otol., Rhin. & Laryng. **51**:689 (Sept.) 1942.

tion of the mucosal lining of the sinus ostiums. This view has now been discarded in the light of recent experimental observations and reconsideration of the histology of the ostiums. Proetz [18d] has emphasized the absence of erectile tissue in the mucosa lining the ostiums. The possibility that vasoconstriction could produce enlargement of the narrowed orifices is somewhat remote. Recent studies [19] indicate that no measurable vasoconstriction occurs on decompression, but vasodilation may well be a part of the physiologic response of the upper respiratory system to lowered atmospheric pressure.

The choice of 10,000 feet as the altitude for therapy has been based on limited trials at various levels. The reduced atmospheric pressure at 10,000 feet represents the lowest oxygen tension at which therapy can be conducted without causing anoxic symptoms in the patients. A limited study of the use of altitudes of 18,000 feet with oxygen equipment revealed no increase in response to therapy, and higher altitudes have been abandoned for the present.

*Subjective Results.*—The striking subjective results of decompression therapy in this series of 125 patients indicate that this method may well become a valuable adjunct to sinus therapeutics. Whether decompression therapy can hold forth the hope of ultimate "cure" is not yet settled, but the high degree of relief that may be afforded to the chronic sufferer is gratifying.

The evaluation of subjective results from any new treatment is difficult, and it must be admitted that much relief afforded patients suffering from a chronic disease is psychic in origin.[14] All clinicians are familiar with the dramatic relief of symptoms of ulcer, sinusitis or rheumatic fever that results in some cases from the use of any new mode of treatment. It is impossible to separate the psychic response from the true relief, and only repeated clinical trials over a long period can ever enable one to judge the ultimate value of the therapy. Nevertheless, it must be pointed out that in chronic sinus disease it is the subjective complaints that bring the patient to the doctor. The symptom complex far outweighs the physical findings in most cases of chronic sinusitis, and it is by relief from subjective complaints that therapy must be evaluated in the final analysis. For these reasons a careful analysis of the relief afforded individual symptoms has been made a part of this study.

The factors determining which patients can best be treated in the decompression chamber are not yet established. Nor can it be predicted in advance which patients will respond to only a few decompression treatments and which will require prolonged therapy. It is quite probable that more intimate knowledge of the pathologic nature of the sinus obstruction in each instance would clarify this question. The obstruction may be due to osseous, fibrous or edematous changes in the nasal tissues, and certainly the simple edematous obstruction will be more easily relieved than obstructions involving bone deformities and fibrous changes. The influence of allergy on the course of sinusitis also may be important, as recurrent inflammatory reactions will be more resistant to therapy than inflammatory processes occurring as residues of a single acute infection of the upper respiratory tract.

*Objective Results.*—The results obtained in the 16 patients who were followed by repeated roentgen studies are interesting. In long-standing sinus disease the thickened mucosal lining of the infected sinuses may be likened to the scar formation occurring after a chronic infection of the skin. The infection may be adequately treated and a clinical cure obtained, but the roentgen picture will still show thickened, fibrosed tissue.[20] The drainage of radio-opaque oils, however, should show an improvement if drainage of the sinuses is improved by therapy. The results of therapy as measured by roentgen methods are not so striking as the subjective results, but the efficacy of decompression therapy is well illustrated.

The marked improvements in hearing occurring in patients with sinus disease who took repeated decompression treatments are similar to the results of like studies in normal persons.[21] The explanation of this phenomenon is not yet clear, but we may hypothesize that the repeated "ascent" and "descent" result in increased efficiency of the middle ear in equalizing pressures. Also the tympanic membrane may become more responsive to pressure differentials.

It is possible that decompression therapy may be of value in treating patients with advanced middle ear deafness due to obstruction of the eustachian tube or to chronic otitis media. At the present time a series of such patients are being treated, but no results are available yet.

One patient, suffering from chronic suppurative sphenoiditis, had shown progressive blindness over a period of several years. The latter condition was thought to be due to inflammatory arachnoiditis with involvement of the optic

19. Butler, D. B.; Greenwood, G. J., and Ivy, A. C.: Unpublished experiments.

20. Jones, E. L.: Iodized Oil as an Aid in the Diagnosis of Chronic Maxillary Sinus Disease, Arch. Otolaryng. **11**:475 (April) 1930. Proetz.[18d]

21. Burkhart, W.; Adler, H., and Ivy, A.: Unpublished data.

nerves. He was given many decompression treatments. At the present time his vision remains unchanged, no progression having occurred.

Three patients over 70 years of age have been regular patients with no untoward results. Their blood pressures and pulse rates were carefully checked on several occasions, and no alterations occurred during decompression. Two patients with cardiac disease were also treated by decompression, but oxygen was given throughout each treatment as a precaution. Their blood pressures and pulse rates did not vary during therapy.

No patients with acute sinusitis have been studied. They have been avoided because of the possible danger of forcing purulent material into the middle ear during "descent." For similar reasons patients with acute infections of the upper respiratory tract were not treated until the acute infection had subsided.

The types of conditions not amenable to decompression treatment are not yet established. It is evident that certain marked obstructive conditions still require radical surgical intervention and that no conservative measures will be of value. It is felt that adequate trial of conservative measures for establishing drainage should possibly always be a prerequisite to surgical treatment. Decompression therapy has the advantage that even when no improvement results from the treatments, no trauma has occurred, and the sinus condition has not been aggravated in any manner.

It will be noted that one of the features of decompression therapy is avoidance of any manipulation or medication of the nasal or sinus tissues. Trauma to these delicate structures has been reduced to a minimum, and it is quite possible that this factor contributes to the results obtained. The education of patients to refrain from use of sprays and drops and from siphonage is difficult but seems worth while. Increasing evidence [22] of the delicacy of the respiratory mucosa points to the powerful mechanisms for combating infection that exist in the nose and to a less extent in the paranasal sinuses. It seems that the promotion of increased drainage and aeration with minimum trauma is all that is required in many cases of sinus disease.

Studies on the effect of lowered atmospheric pressures on the paranasal sinuses are few. Gurkov [23] reported the changes of pressure in the frontal sinuses of cats and dogs on slow "ascent" and rapid "descent" in the decompression chamber. In animals under anesthesia induced with ether (possible mucosal engorgement with sinus obstruction?) the pressure in the frontal sinuses became positive on "ascent" until a height of 6,000 to 8,000 meters was reached (19,600 to 26,250 feet); then the pressure began to drop and became negative at 10,000 meters (32,800 feet). The causes of the negative pressure at 10,000 meters are not discussed. Rapid "descent" produced negative pressures as low as —25 to —35 mm. of water, and marked hyperemia and hemorrhage of the mucosal lining of the sinuses occurred. Gurkov suggested that the rapid descent of airplanes produces similar negative pressures in man and may be the cause of the severe frontal headaches so often reported. Animals under anesthesia induced with ethyl carbamate did not show any changes of pressure on slow "ascent" but did show development of negative pressures on rapid "descent" (no mucosal engorgement?).

Parfenov [24] reports the production of typical sinus headaches by rapid "descent" in the decompression chamber.

These studies by the Russian workers explain the many observations in this country that severe symptoms may develop in flyers with sinus disease and that their sinusitis is often aggravated by flying.[25] It should be pointed out that these observations are based on slow ascent and rapid descent, such as occurs in airplane flights, while decompression therapy is based on the opposite conditions of rapid "ascent" and slow "descent."

Behnke [26] reported the use of increased atmospheric pressures in the diagnosis and treatment of sinusitis. He placed his patients in a compression chamber and slowly increased the atmospheric pressure to twice normal atmospheric pressure (a positive pressure of 15 pounds per square inch [1 Kg. per square centimeter]). Then, by rapidly releasing the pressure, he obtained drainage and marked relief in some cases. The principle of slow compression and rapid decompression used by Behnke is identical with the principle of rapid decompression and slow compression that we have used in the high altitude

22. Hilding.[13b] Fenton.[13c] Proetz.[13d]

23. Gurkov, A. D.: Significance of Nasal Sinuses in Pathogenesis of Headache During Training in Barometric Chamber and During High Altitude Flights: Effect of Rarified Atmosphere on Pressure in Frontal Sinuses, Med. zhur. **11**:305, 1941.

24. Parfenov, A. C.: Influence of Reduced Atmospheric Pressure on Ear and Nasal Sinuses, Zhur. ush., nos. i gorl. bolez. **15**:594, 1938.

25. Carson, L. D.: Otolaryngologic Problems Occurring in Fliers, J. A. M. A. **120**:4 (Sept. 5) 1942. Pentecost, R. S.: Some Observations on Ear, Nose, and Throat Disabilities Associated with Aviation, Canad. M. A. J. **47**:314 (Oct.) 1942.

26. Behnke, A. R., Jr.: High Atmospheric Pressures: Physiological Effects of Increased and Decreased Pressure; Application of These Findings to Clinical Medicine, Ann. Int. Med. **13**:2217 (June) 1940; footnote 2.

chamber. He also suggested that the development of severe pains in the sinuses on fairly rapid compression is indicative of sinus disease and may be a means of diagnosis. One wonders if such diagnostic use of positive pressure might not force additional infected material to enter noninfected areas and traumatize sinuses already infected.

## SUMMARY AND CONCLUSION

Of 125 patients who were treated for chronic sinus disease in a high altitude chamber by rapid decompression of atmospheric pressure to 522.6 mm. of mercury, 89.5 per cent experienced subjective improvement at the conclusion of their course of treatment.

Of 29 patients who were followed by serial roentgen studies after instillation of radio-opaque oils, 17, or 58.6 per cent, showed improvement in the roentgenogram after the decompression treatments.

Of 42 patients who were studied by repeated rhinologic examinations, 30, or 71.4 per cent, showed improvement in their sinus condition after being treated by decompression.

A total of 2,259 treatments were given. The average number per patient was 18.1.

Decompression therapy is a simple nontraumatic form of treatment for subacute and chronic sinus disease.

303 East Chicago Avenue.

# TOTAL LARYNGECTOMY

## SIMPLIFIED TECHNICS WITH THE USE OF A SPECIAL CLAMP WHICH MAKES POSSIBLE THE REMOVAL OF THE LARYNX AND PREEPIGLOTTIC SPACE WITHOUT OPENING THE PHARYNX

EDMUNDO VASCONCELOS AND PLINIO DE MATTOS BARRETTO

SÃO PAULO, BRAZIL

We have been working in close cooperation on the surgery of cancer of the larynx and have published a paper presenting in detail our views concerning surgical indications and describing our technic of laryngectomy.[1] Recently we have been using a new technic [2] for this operation, more conservative than the one previously described by us. Both technics will be described in this article so as to make their differences and the indications for each well understood.

In both operations the preepiglottic space is removed entirely and simultaneously with the larynx. The manner of spreading of a tumor at the base of the epiglottis and ventricular bands, well established by Leroux-Robert, makes it probable that in a large number of cases the removal of the tumor cannot be accomplished with safety if the preepiglottic space is not removed as well as the larynx. By using a special clamp (fig. 1) it is possible to remove the larynx and preepiglottic space in a single block, and the suturing of the pharynx, which is kept closed during the entire operation, becomes simple and safe.

### ANESTHESIA

To induce general anesthesia for laryngectomy we have been using solution of tribromoethanol in amylene hydrate in a dosage of 0.08 to 0.10 Gm. per kilogram of body weight; this anesthetic is given fifteen minutes before the operation.

To reenforce the action of tribromoethanol and diminish secretions we use a preparation containing morphine hydrochloride, scopolamine hydrobromide and sparteine sulfate (sedol). This is given by subcutaneous injection one-half hour before the solution of tribromoethanol. In a few cases it has been necessary to put patients more deeply asleep by supplementary intratracheal insufflation of ether.

This method of inducing and maintaining anesthesia was found to have the following advantages: perfect tolerance on the part of the patient; no inconvenience from renal, cardiovascular or respiratory disturbances; perfect muscular relaxation with maintenance of the cough reflex.

### THE CONSERVATIVE TOTAL LARYNGECTOMY

The conservative total laryngectomy is a "narrow field" [3] operation performed in the midline, perhaps with as good an anatomic basis as the operation proposed by Crowe and Broyles. It is also simple and quickly done, and enables one to avoid major trauma to the normal tissues, which retain a good blood supply. With the special technic for the suturing of the pharynx, the possibility of contamination of the operative wound is greatly decreased, as well as the possibility of fistula. Furthermore, the most important anatomic structures that could aid in the development of the esophageal or pharyngeal voice are preserved, and patients can expect to be able to take liquids by mouth on the third to the fifth postoperative day and to leave the hospital in less than two weeks.

This should be the operation of choice in the cases of intrinsic tumor in which partial laryngectomy would be considered unsuitable, including, however, cases in which there is possible invasion of the preepiglottic space.

### SUMMARY OF THE STEPS IN THE CONSERVATIVE OPERATION

*First Step. Incision.*—A midline incision is made from a half centimeter above the level of the hyoid bone to the level of the inferior border of the isthmus of the thyroid gland (fig. 2). This incision should be

From the Faculty of Medicine of the University of São Paulo.

1. Vasconcelos, E., and de Mattos Barretto, P.: A cirurgia no tratamento de cancer da larynge, Rev. de cir. de São Paulo, November 1943.

2. de Mattos Barretto, P.: Nova tecnica de laringectomia total. This note was read before the section on ear, nose and throat of the Associacão Paulista de Medicina, Oct. 18, 1943.

3. This term was suggested by Chevalier Jackson (Laryngectomy: Plea for Narrow Field Operation. Surg., Gynec. & Obst. **70**:517, 1940).

made through the skin, the subcutaneous tissues and the superficial cervical aponeurosis. Then the linea alba is opened so as to expose the hyoid bone and the thyrohyoid membrane in the midline, the anterior border of the thyroid cartilage, the anterior part of the cricoid ring and the isthmus of the thyroid gland.

*Second Step. Ligation of the Pedicles of the Inferior Laryngeal Arteries.*—At each side the sternohyoid muscle is carefully retracted laterally to expose the line of insertion of the sternothyroid and thyrohyoid muscles. Over that line runs the pedicle of the inferior laryngeal artery, which should be ligated close to the anterior border of the sternohyoid muscle (fig. 3 *A*).

*Third Step. Section of the Isthmus and Separation of the Lobes of the Thyroid Gland.*—Depending on the size of the isthmus, the thyroid gland is separated from the cricoid and first tracheal rings and retracted down, or the isthmus is sectioned and sutured. Cutting across the isthmus greatly facilitates the exposure of the laryngeal artery can easily be found where it goes through the thyrohyoid membrane.

*Sixth Step. Section of the Cricoid Cartilage or Section of the Trachea.*—The trachea or the cricoid cartilage is sectioned obliquely from anterior to posterior and from below upward. (The level of the section should have been established by preoperative studies; thus the surgeon is enabled to know whether or not part of the cricoid ring may be preserved to build a tracheal stoma which will not require the use of a tracheal cannula.) As soon as the trachea is cut across, hemorrhage from two small arterial vessels, the posterior laryngeal arteries, which run parallel on the posterior surface of the trachea, must be stopped quickly so as to prevent aspiration of blood. An aspirator may be helpful if used with care to avoid contamination of the wound.

*Seventh Step. Freeing of the Posterior Surface of the Cricoid and That of the Thyroid Cartilage.*—A small

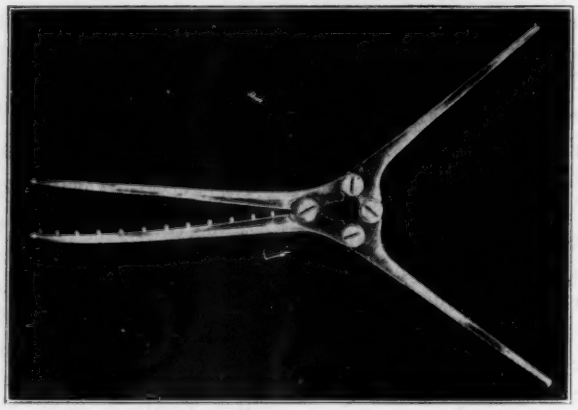


Fig. 1.—The original Vasconcelos clamp, especially devised for the suturing of the pharynx. Barretto's modification of the Vasconcelos clamp consists in having teeth in both blades of the clamp instead of in only one blade. This aids greatly in preventing the escape of the pharyngeal mucosa when the larynx is removed.

larynx; it also prepares the field for a tracheotomy that may be necessary to avoid dyspnea or to enable anesthesia to be deepened by intratracheal insufflation.

*Fourth Step. Section of the Body of the Hyoid Bone, Freeing of Its Posterior Surface and Separation of the Mylohyoid Muscles* (fig. 3 *B*).—The hyoid bone is sectioned in the midline, and the mylohyoid muscles are separated for a distance of 1 cm. Then it becomes quite easy to free the posterior surface of the hyoid bone, which is separated from the preepiglottic space by Boyer's bursa. The section of the hyoid bone with the separation of the mylohyoid muscles not only makes possible the use of Vasconcelos' clamp but greatly facilitates the exposure and ligation of the pedicles of the superior laryngeal arteries.

*Fifth Step. Exposure of the Thyrohyoid Membrane and Thyroid Cartilage; Ligation of the Pedicles of the Superior Laryngeal Arteries* (fig. 4 *A*).—With scissors the insertions of the sternothyroid and thyrohyoid muscles are cut very close to the thyroid cartilage. If the muscles are pulled aside with long blade retractors and the larynx is drawn to the other side, the posterior border of the cartilage covered by the constrictors of the pharynx can be well exposed. At the angle formed by the superior cornu and the superior border of the thyroid cartilage the pedicle of the superior swab of gauze is placed in the subglottis, and by pulling upward with a hook the larynx is lifted as it becomes separated from the pharynx by scissors dissection (fig. 4 *B*). When the larynx is isolated and raised up, stitches should be placed to fix the trachea or the cricoid ring to the border of each sternohyoid muscle. The dissection of the posterior surface of the cricoid is then carried upward until the transverse fibers of the arytenoideus transversus muscle are reached. The pharyngeal wall is separated off from the posterior surface of the thyroid cartilage all the way up, and the superior cornua are cut across. After this is done, the larynx and the preepiglottic space are ready to be removed.

*Eighth Step. Removal of the Larynx and Suturing of the Pharynx.*—The gauze is removed from the subglottis, and through the latter a hook is introduced to catch the epiglottis and retract it downward to avoid its being caught between the blades of the clamp (fig. 5). As the hook and the larynx are lifted, the forceps are carefully applied and closed. With a scalpel the incision is carried along close to the concave surface of the forceps, and care is taken not to contaminate the operative wound by contact with the laryngeal mucosa which still remains clamped in the forceps. A continuous suture with no. 1 silk or catgut is placed be-

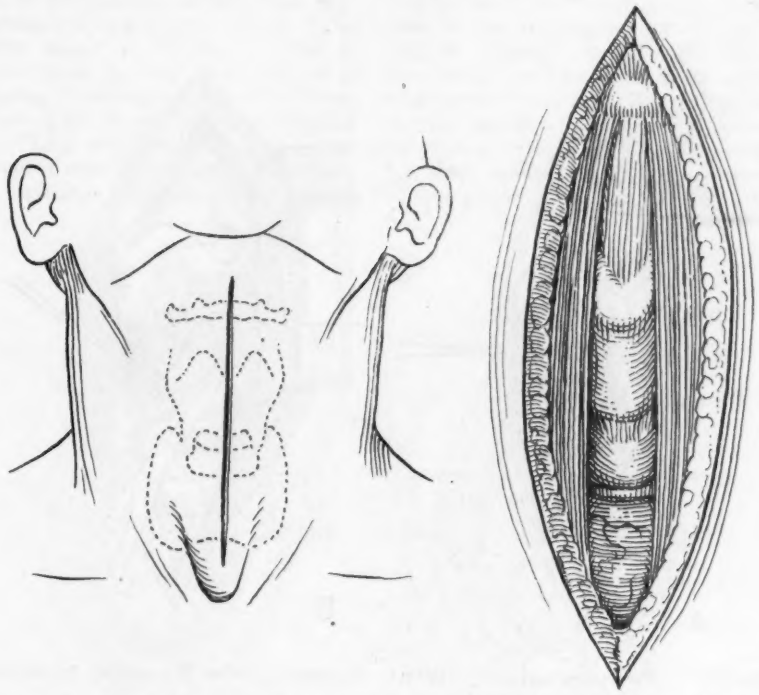


Fig. 2.—First step of the conservative technic: Showing the incision and exposure of the hyoid bone, the thyrohyoid membrane, the anterior border of the thyroid cartilage, the anterior part of the cricoid ring and the isthmus of the thyroid gland.

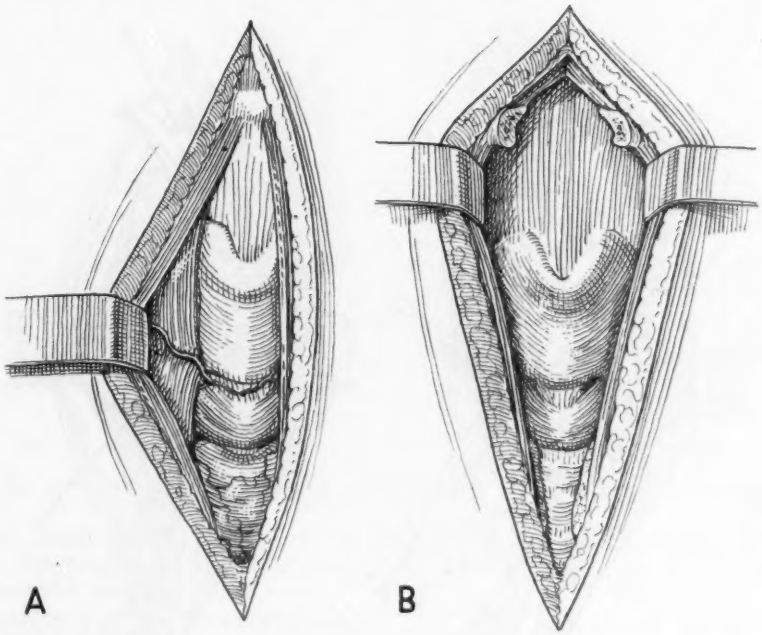



Fig. 3.—*A*, second step in the conservative operation: Exposure of the line of insertion of the sternothyroid and thyrohyoid muscles for ligation of the inferior laryngeal pedicle.

*B*, fourth step in the conservative operation: Section of the body of the hyoid bone, freeing of its posterior surface and separation of the mylohyoid muscles.

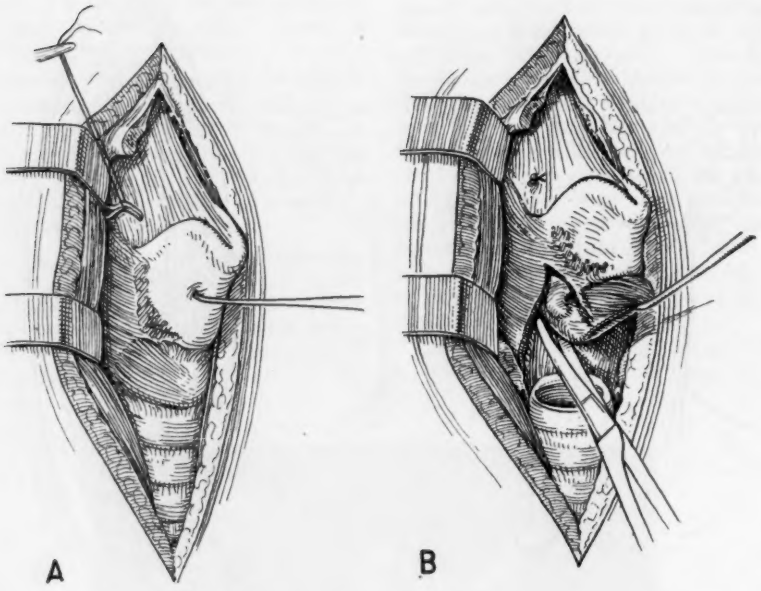



Fig. 4.—*A*, fifth step in the conservative operation: Exposure of the thyrohyoid membrane and thyroid cartilage; ligation of the superior laryngeal pedicles.

*B*, seventh step in the conservative operation: Scissors dissection of the larynx from the pharynx and lifting of the larynx by a hook.

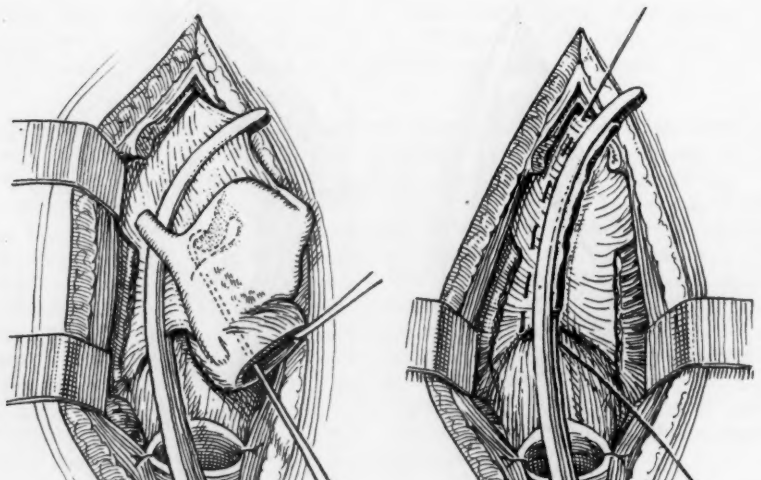


Fig. 5.—Eighth step in the conservative technic: Removal of the larynx and suturing of the pharynx.

neath the forceps. One assistant maintains tension on the two extremities of this thread, which is not tied, while the surgeon opens and removes the forceps. The pharynx still remains closed by the thread which is held by the assistant. Over the first suture, which is only temporary, another continuous suture of chromic catgut no. 000 or no. 0000, is placed in the Cushing manner (fig. 6 *A*). This suture is to be reenforced by a series of interrupted stitches with the same catgut. The temporary silk thread is now removed by pulling

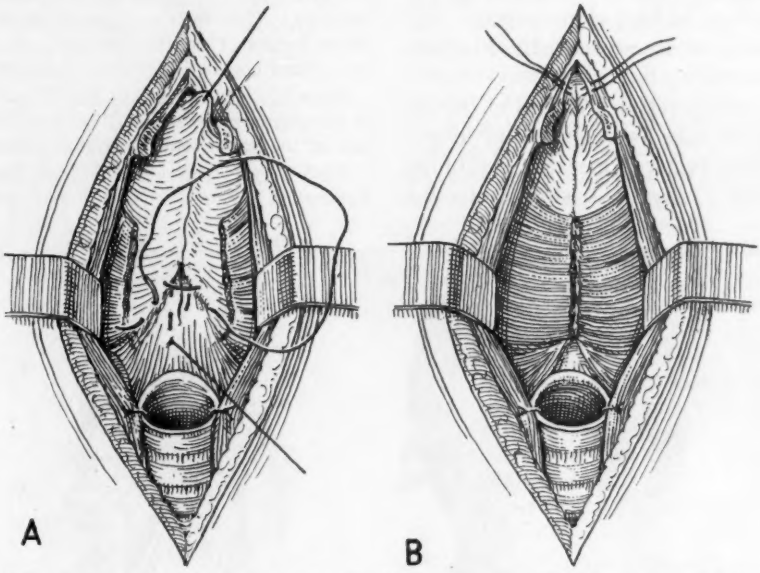



Fig. 6.—*A*, placing of the second sutures in the Cushing manner. (Eighth step). *B*, ninth step in the conservative technic: Approximation of the constrictor muscles of the pharynx.

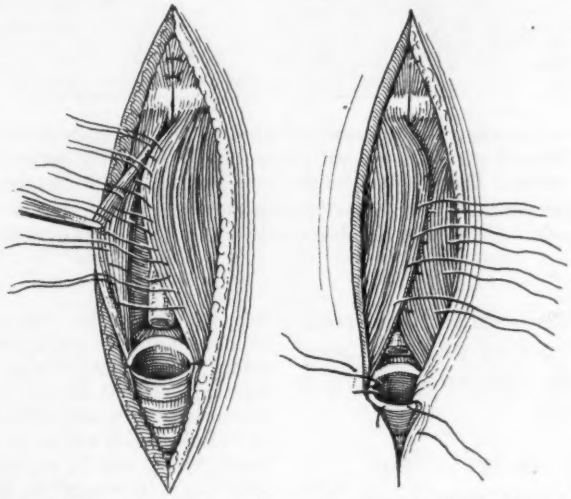


Fig. 7.—Use of the Crowe and Broyles technic in the overlapping of the prelaryngeal muscles (ninth step).

one end. The compressed and cut surface of the pharyngeal mucosa now remains within the pharynx, this being done by inversion with the Cushing suture.

*Ninth Step. Reenforcement of the Pharyngeal Suture; Drainage and Closure of the Operative Wound.*—After all bleeding points have been carefully clamped, the constrictor muscles of the pharynx are approximated by interrupted stitches so as to make an almost complete muscular cover of the pharyngeal suture line (fig. 6 *B*). The mylohyoid muscles are also approximated by one or two stitches, including the tissues of the base of the tongue without transfixing the mucosa. Finally the technic proposed by Crowe and Broyles is used in the overlapping of the prelaryngeal muscles (fig. 7). Similar closure of the skin and drainage are also used. A tracheal cannula, wrapped with gauze impregnated with sulfanilamide paste, is placed in the tracheal stoma. The upper part of the suture line of the skin is covered with sulfanilamide powder; this is not used inside the wound. The postoperative care is that advised by Crowe and Broyles. One day preoperatively sulfanilamide therapy is started, and it is maintained for five or six days postoperatively.

## THE AMPLIFIED LARYNGECTOMY

When we have thought that the prelaryngeal muscles should be removed as well as the larynx and the preepiglottic space, we have used another technic, a "wide field" [3] operation in which even the hyoid bone is removed. A midline incision

could be used, but in order to facilitate the ligation of the arterial pedicles and the removal of the hyoid bone, we have frequently used a "collar" incision such as that used by Jackson and Babcock,[4] fastening the tracheal stump to the skin in a separate small circular "buttonhole" incision. To avoid the formation of "dead spaces" beneath the suture line of the cutaneous flap, a rubber sponge is used in the dressing, and drainage is maintained as long as necessary. We have used this technic in more than 20 cases without a single operative fatality.

After this type of operation the period during which postoperative care is required is longer than after the conservative operation, running from fifteen to thirty days. A slight infection in the operative wound has frequently occurred, and in 1 case, that of a syphilitic patient in poor general condition, a fistula occurred requiring a plastic operation for closure.

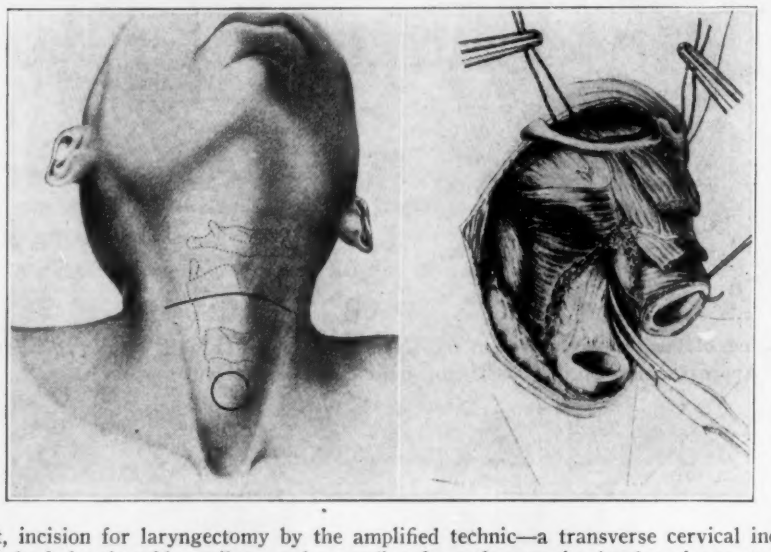


Fig. 8.—At left, incision for laryngectomy by the amplified technic—a transverse cervical incision at the level of the superior third of the thyroid cartilage and extending from the anterior border of one sternomastoid muscle to the anterior border of the other. The circular "button hole" incision for the tracheal stoma is also shown.

At right, eighth step in the amplified operation: freeing of the posterior surface of the larynx after incision of the inferior constrictor muscle. (Note that muscles, preepiglottic space and hyoid bone are going to be removed with the larynx.)

## SUMMARY OF THE STEPS IN THE AMPLIFIED OPERATION

*First Step. Incision of the Skin and the Platysma Muscle.*—With the patient in the dorsal decubitus and with the head in hyperextension, a transverse incision is made at the level of the superior third of the thyroid cartilage, extending from the anterior border of the sternocleidomastoid muscle on one side to the corresponding point on the other side, the incision dividing the skin and the platysma muscle. The anterior jugular veins are found, ligated and sectioned (fig. 8).

*Second Step. Section of the Superficial Cervical Aponeurosis and Detachment of Flaps.*—The aponeurosis is sectioned at the same level as the skin. One flap is detached, including in one block skin, platysma muscle and superficial aponeurosis. Upward the detachment should be made to a little above the hyoid bone, and downward, to the level of the isthmus of the thyroid gland. Laterally it should reach and even go a little beyond the anterior borders of the two sternocleidomastoid muscles.

*Third Step. Section of the Omohyoid and Sternohyoid Muscles.*—This section is made at the level of the inferior border of the thyroid cartilage, each muscle being in its turn elevated and then sectioned.

*Fourth Step. Location and Ligation of the Pedicles of the Inferior Laryngeal Arteries.*—This step is carried out in the same way as in the conservative operation.

*Fifth Step. Section of the Sternothyroid Muscles and Separation of the Lobes of the Thyroid Gland.*—On each side we isolate the muscle, elevating it with care so as not to injure the internal branch of the superior artery which, accompanied by venous branches, is distributed over the superior border of the thyroid gland and anastomoses with that of the opposite side. Branches of these arteries extend to the posterior surface of the sternothyroid muscle, and others are found to anastomose with the arch formed by the inferior laryngeal arteries. These branches have to be clamped and ligated. This done, it is easy to retract the lobes of the thyroid gland. Sometimes it is convenient to section the isthmus of this gland to leave the cricoid ring quite free.

*Sixth Step. Ligature of the Pedicles of the Superior Laryngeal Arteries.*—This step is carried out as in the conservative operation, step 5. The nerve, which always runs above the artery, joins it to go through the membrane. When general anesthesia is used, it is not thought necessary to block the nerve before sectioning.

*Seventh Step. Section of All Muscles with Insertions into the Superior Border of the Hyoid Bone.*—The electric knife is used, which has to be applied always in

4. Jackson, C., and Babcock, W. W.: Laryngectomy for Carcinoma of the Larynx, S. Clin. North America **11**:1207, 1931.

contact with the bone to avoid injury to the hypoglossal nerve or the lingual artery, and this procedure is facilitated by retracting the larynx downward by means of a hook fixed in the thyrohyoid membrane, close to the median notch of the thyroid cartilage. Thus the structures with insertions in the superior

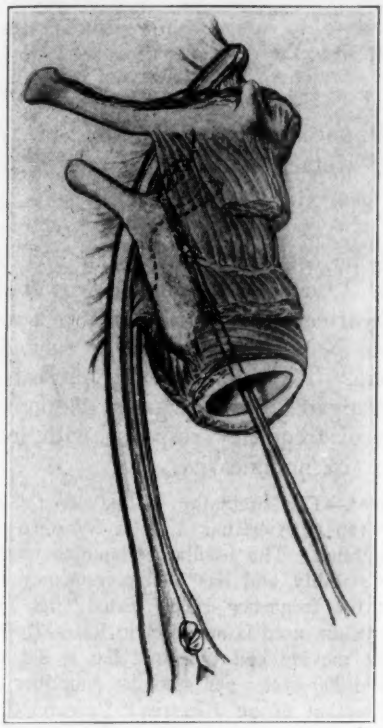


Fig. 9.—Application of the clamp and use of the hook for the epiglottis in the amplified operation.

border of the hyoid bone are also maintained under tension.

*Eighth Step. Section of the Cricoid Cartilage or the Trachea, Section of the Constrictor Muscles of the Pharynx, and Freeing of the Posterior Surfaces of the Cricoid and Thyroid Cartilages.*—These procedures should be executed as described in the conservative operation, steps 6 and 7 (figs. 4*B* and 8).

*Ninth Step. Preparation of the Cutaneous Orifice and Fixation of the Tracheal Stump to the Skin.*—Even before complete isolation of the posterior surfaces of the cricoid and thyroid cartilages a circular opening in the skin should be made at the point where the center of the tracheal stoma is to be placed. Then with scissors the superficial cervical aponeurosis should be opened and communication established with the large operative wound. The tracheal stump is to be mobilized from the esophagus, the dissection not to extend down too far. Four no. 1 silk threads are passed beneath the cricoid or the tracheal ring, and all of them are grasped at the same time with a forceps passed through the cutaneous orifice. By means of these threads the superior extremity of the trachea is now pulled to the level of the cutaneous orifice, and with these four threads the tracheal stoma is sutured to the skin. Mucocutaneous sutures then complete the approximation of the skin with the mucosa, and this approximation should be as perfect as possible. A tracheal cannula is inserted in the tracheal stoma.

*Tenth Step. Removal of the Larynx, the Preepiglottic Space and the Hyoid Bone, and Suturing of the Pharynx* (fig. 9).—This should be done in essentially the same way as described in connection with the conservative operation, step 8, the only difference being that the clamp includes in a single block the prelaryngeal muscles, the larynx, the preepiglottic space and the hyoid bone, instead of just the larynx and the preepiglottic space.

*Eleventh Step. Approximation of the Mylohyoid Muscles and Reenforcement of the Suture Line of the Pharynx.*—The mylohyoid muscles are approximated in the midline by interrupted sutures, as are also the constrictor muscles of the pharynx. The reenforcement of the pharyngeal suture line must be limited to these two muscles.

*Twelfth Step. Drainage and Closure of the Skin.*—Drainage is established by the insertion of two rubber tubes (no. 16 French), one on each side, lateral to the stoma, in stab wounds. Closure of the skin is accomplished by a continuous suture of no. 1 chromic catgut, approximating the superficial cervical aponeurosis and the platysma muscle. When this suture is performed correctly, such a good approximation of the cutaneous borders is obtained as to render any special suturing of the skin unnecessary.

# PHYSICAL CHARACTERISTICS OF SOME BONE OSCILLATORS USED WITH COMMERCIALLY AVAILABLE AUDIOMETERS

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One of the positive recommendations of the Committee on Methods of Testing Hearing by Bone Conduction (chairman, Stacy R. Guild, Ph.D.)[1] is "that tests of the hearing by bone conduction be made for as great a range of frequencies as possible with the available instruments, always with due regard to the possible sources of errors."

In this paper we report the results of physical tests to which two common types of commercially available bone oscillators for audiometers were subjected in an investigation of some sources of errors.

According to definition, the measuring of the threshold of hearing or any other sensation above threshold by means of an audiometer should be done with a tone of defined purity and of defined intensity. This holds for air as well as for bone conduction. The investigation was therefore concerned with two problems: First, can the intensity of the bone-conducted sound be determined sufficiently by present methods of clinical audiometry, and is use of the term "loss in decibels" permissible? Further, what are the physical causes of inaccuracy? Second, is the output of the bone oscillator a pure tone if the input is an alternating voltage of one frequency only, or are new frequencies generated in the bone oscillator owing to the mechanical characteristics of the latter? In other words, what is the nonlinear characteristic of the bone oscillator?

The paper contains some technical terms used in acoustics but not yet common in otologic literature. The reader is referred to standard textbooks on acoustics, such as Stewart and Lindsay,[2] Morse,[3] Richardson [4] and others.

## EXPERIMENTS

Two bone oscillators have been investigated, A and B. Oscillator A is of the type commonly used in hearing aids. Oscillator B is a rod connected to an electromagnetically excited driving system. The following characteristics have been investigated: (*a*) frequency response; (*b*) variation of frequency response with load impedance; (*c*) nonlinearity.

*Equipment.*—The oscillator is the R. C. A. beat frequency type. Amplifier 1 is a Western Electric power amplifier. The oscillator-amplifier combination has good stability and has a flat frequency response curve for the frequency range tested (fig. 2). The vibration pickup used is an Electric Research Products unit of the moving coil type and has a flat response curve above 200 cycles per second. Amplifier 2 is the amplifier section of an Electrical Research Products sound analyzer, the filter section of which is of the crystal type. The band width of the filter is adjustable either to 5 or to 50 cycles per second. The high speed level recorder unit has a stylus speed of 100 decibels per second. The harmonic content of the oscillator-amplifier section was measured with a General Radio wave analyzer. The output was found very pure, the harmonic content being negligible. The highest content of second harmonic was found to be 0.18 per cent at 500 cycles per second. The fundamental voltage output was approximately 2.5 volts. A determination was also made of the amount of the 60 cycle hum and its harmonics as generated by the oscillator-amplifier combination and was found to be negligible. The linearity of the whole electrical system was established by use of the test setup of figure 1 *C*. The voltage output was fed directly into the analyzing system, and a record was taken of the frequency spectrum of this voltage. No harmonics were found; hence the electrical system was linear.

*Measurement of Frequency Response.*—The bone oscillator is mounted as shown in figure 3 and is attached to the vibration pickup by means of a rubber band under tension. The tension is approximately 4 pounds (1.8 Kg.). Rubber pads 1/16 inch (1.5 mm.)

* It is to be understood that the opinions or assertions stated in this paper are the authors' own and are not to be construed as official or as reflecting the views of the Navy Department or the Naval Service at large.

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1. Report of the Committee on Methods of Testing Hearing by Bone Conduction, Ann. Otol., Rhin. & Laryng. **45**:800, 1936.

2. Stewart, G. W., and Lindsay, R. B.: Acoustics, New York, D. Van Nostrand Company, Inc., 1930.

3. Morse, P. M.: Vibration and Sound, New York, McGraw-Hill Book Company, Inc., 1936.

4. Richardson, E. G.: Sound, ed. 3, London, Edward Arnold & Co., 1940.

thick are inserted between the bone oscillator and the surface of the vibration pickup. The latter is embedded in a cylinder of Pakseal (a putty-like material manufactured by the Johns Manville Company) weighing 2,290 Gm. The cylinder is supported by a single wire attached to a steel frame. The electrical system used is shown in figure 1 *A*. An oscillator feeds into an amplifier the output of which is used to drive the bone oscillator. The velocity level of the vibrations of the latter is converted into voltage by the vibration pickup. The alternating voltage thus produced is fed through an amplifier to a high speed level recorder. The stylus of the recorder writes on a strip of paper which moves with uniform speed. The vertical motion of the stylus is proportional to the decibel level of the input voltage to the recorder. A frequency response curve is obtained by continuously varying the oscillator frequency, keeping the output voltage of the oscillator constant and taking a record of the velocity level produced by the bone conductor. The continuous variation of frequency is produced by driving the oscillator frequency control dial with a constant speed motor.

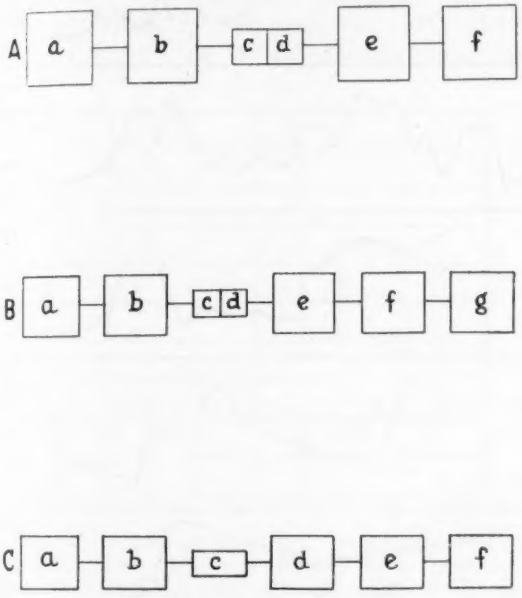


Fig. 1.—*A*, apparatus for producing frequency response curves: (*a*) oscillator, (*b*) amplifier 1, (*c*) bone oscillator, (*d*) vibration pickup, (*e*) amplifier 2, (*f*) recorder.

*B*, apparatus for producing nonlinearity curves: (*a*) oscillator, (*b*) amplifier 1, (*c*) bone oscillator, (*d*) vibration pickup, (*e*) analyzer, (*f*) amplifier 2, (*g*) recorder.

*C*, apparatus for checking linearity of a driving system: (*a*) oscillator, (*b*) amplifier 1, (*c*) attenuation pad, (*d*) analyzer, (*e*) amplifier 2, (*f*) recorder.

*Measurement of Variation of Frequency Response with Load Impedance.*—Frequency response curves are taken under the following conditions:

1. The vibration pickup is embedded firmly in the pakseal cylinder. The end of the pickup is solidly pressed against the bottom of the hole made in the putty to accommodate the pickup; the cylindric surface of the pickup is gripped tightly by the pakseal. This corresponds to large mass reactance and large resistance of the load impedance.

2. The vibration pickup is embedded loosely in the pakseal cylinder. The end of the pickup is pulled away from the bottom of the hole in the putty. This corresponds to large resistance and smaller mass reactance than in 1.

3. The pakseal cylinder is removed altogether, and a piece of metal is substituted for it. This corresponds to large mass reactance and smaller resistance than in 1 and 2.

4. All load is removed from the pickup. This corresponds to a smaller mass reactance and smaller resistance of the load impedance than in 1, 2 or 3. The exact value of each load impedance has not been measured but the general character is evident.

*Measurement of Nonlinearity.*—The electrical system used is shown in figure 1 *B*. The oscillator is set to deliver a single frequency sinusoidal voltage, which is fed into the bone conductor under test through an amplifier. The mechanical output of the bone conductor is converted into electrical voltage by the vibration pickup. This voltage is fed into a crystal filter and then through an amplifier, and the output from the amplifier is recorded. The filter is motor driven so that the record obtained represents a continuous frequency analysis of the mechanical output of the bone oscillator. The reason for this type of test is to determine whether the bone conductor gives a pure single frequency mechanical output when a pure single frequency voltage is applied to it.

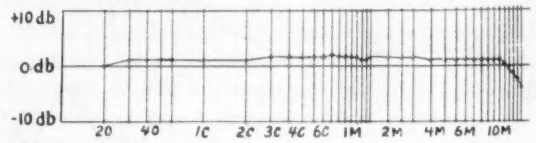


Fig. 2.—Curve 1. The frequency response curve of the driving system.

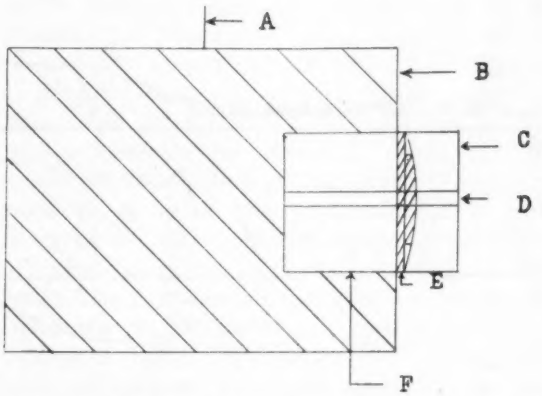


Fig. 3.—Experimental setup: A container filled with putty (*B*) is suspended on a steel wire (*A*) in a steel frame. The bone oscillator (*C*) is connected to the vibration pickup (*F*) by means of a rubber band (*D*). A rubber pad (*E*) is inserted between the bone oscillator and the vibration pickup.

## RESULTS

*Frequency Response Curves of Bone Conductor A.*—Three successive frequency response

curves were taken, one immediately after the other. Curve 2 (fig. 4) is one of these. The pickup was set tightly in the putty (condition 1), and no changes were made in the system during these runs. The curves show the same general trends but differ markedly in details. All three curves show peaks in the regions of 700 and 1,000 to 1,500 cycles per second and in the neighborhood of 2,700 cycles per second. However, these peaks differ in breadth, height and structure, which indicates that the load impedance changed between runs. This may have been due to a slight alteration of position of the vibration pickup in the putty, which could have been caused by the vibration of the pickup while under test.

Curve 3 is a frequency response curve taken after the vibration pickup had been loosened in the putty (condition 2). All other conditions were the same as before. Curve 3 has an entirely different structure from the aforementioned three curves. The output level is generally higher than that under condition 1. This was to be expected since the over-all impedance had been reduced. The peak at 170 cycles per second is more pronounced, the response in the region of 200 to 1,200 cycles per second is higher and smoother. In particular the valley from 500 to 1,000 cycles in curve 2 has been removed. The same applies to the peak at 2,700 cycles.

Curve 4 is the result of a run with the putty replaced by a mass of metal (condition 3). The

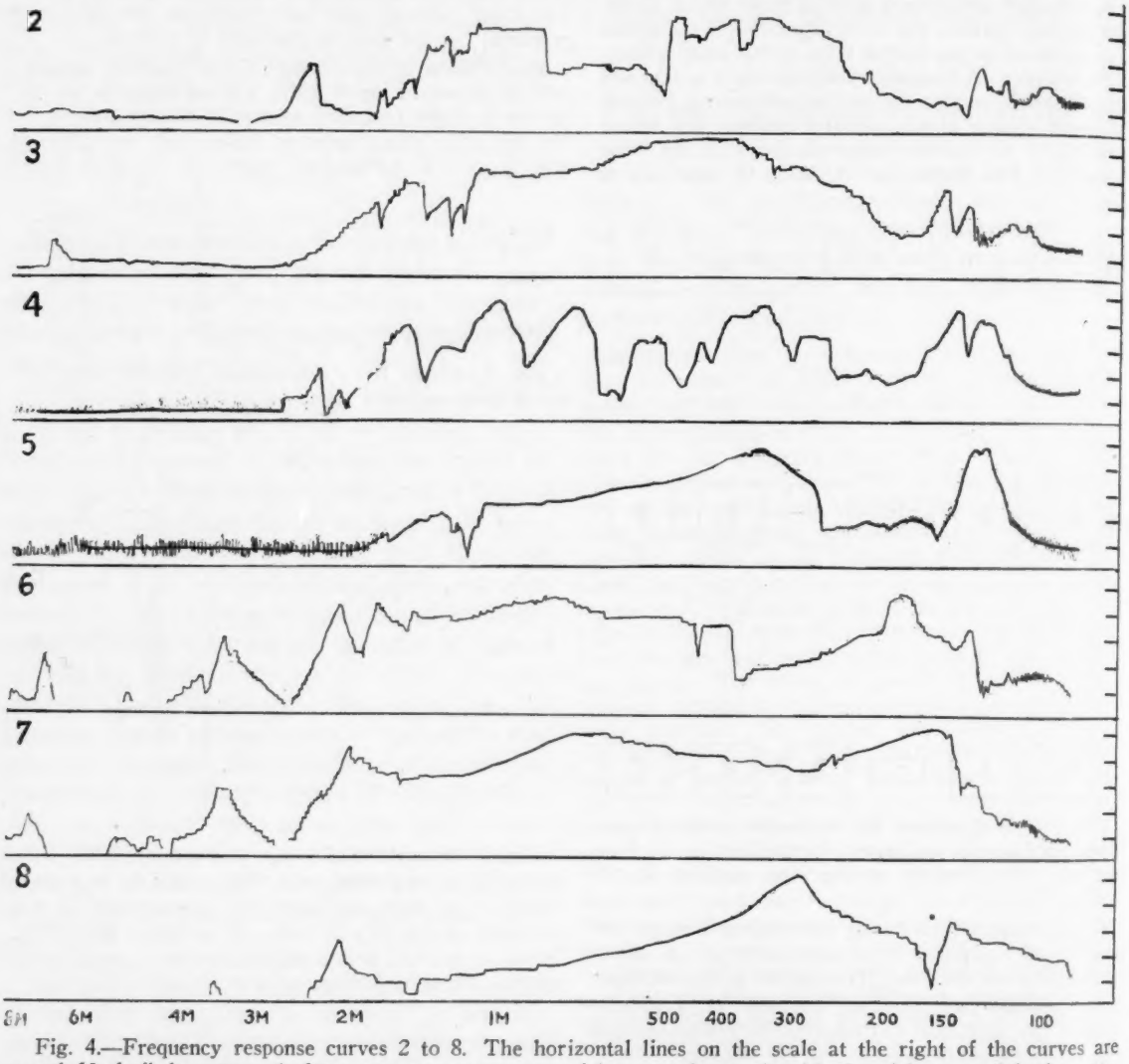


Fig. 4.—Frequency response curves 2 to 8. The horizontal lines on the scale at the right of the curves are spaced 10 decibels apart. *2*, frequency response curve of bone conductor A with the pickup set tight in putty. *3*, frequency response curve of bone conductor A with the pickup loosened in putty. *4*, frequency response curve of bone conductor A with the putty replaced by a steel block. *5*, frequency response curve of bone conductor A loaded by the pickup alone. *6*, frequency response curve of bone conductor B with the pickup tight in putty. *7*, frequency response curve of bone conductor B with the pickup loosened in putty. *8*, frequency response curve of bone conductor B loaded by the pickup alone.

character of this curve is different from all preceding ones. The original peak at 170 cycles per second has been transformed into two peaks, each higher than the original. The rest of the curve shows marked peaks and valleys. Curves of duplicate runs are not identical, which indicates that small changes of position between the different parts of the structure under test and beyond the control of the investigators produce a change of the frequency characteristic of the bone oscillator under test.

Curve 5 is one of three runs made with the pickup having no load impedance (condition 4). These differ from all preceding curves but are practically identical with each other. This confirms the explanation of the variation of repeated response curves, that the variation is due to shift in load impedance between runs since when the load impedance is only that due to the pickup (which impedance most probably does not change between runs) identical response curves are obtained.

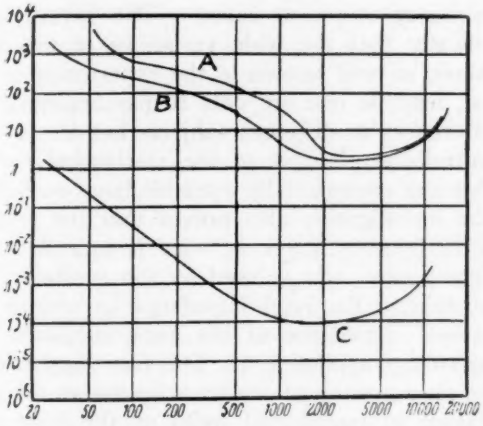


Fig. 5.—Comparison between a normal air conduction threshold curve (*C*) and normal bone conduction threshold curves (*A* with external canals of the ears open and *B* with external canals closed). The threshold values (left) are given in dynes per square centimeter. The test frequencies are given at the foot of the chart. After Békésy.[13]

*Frequency Response Curves of Bone Conductor B.*—Curve 6 is a frequency response curve taken with the pickup tight in the putty. A duplicate run was made immediately afterward. Except in the region between 200 and 400 cycles per second they agree closely. This may be explained by the assumption that, although the vibratory motion of the bone conductor may have slightly shifted the position of the pickup in the putty, nevertheless the corresponding change in load impedance was small enough not to affect the output of the relatively powerful bone conductor B. The curves show peaks in the vicinity of 200, 1,000, 1,800, 2,200, 3,500 and 7,300 cycles per second. Curve 7 is a response curve with the pickup loose in the putty. It differs considerably from curve 6 in showing much more uniform response from 200 to 2,000 cycles per second. The peaks at 3,500 and 7,300 still remain. Curve 8 is a frequency response curve made with the vibration pickup having no load impedance. A duplicate run was made immediately afterward, and the curves were found to be in excellent agreement with each other.

*Nonlinearity.*—The data on nonlinearity in the accompanying table show the presence of considerable amounts of harmonics in the outputs of the bone conductors even though a single frequency voltage was applied. The voltages were chosen in such a way as to produce loudness sensation well above threshold with the bone conductor placed over the mastoid process and the external canal of the ear open in a person 30 years of age with normal hearing. The purpose of this procedure was to duplicate the conditions of actual audiometric testing. It may be added that tests at the higher voltages necessary to produce the required mechanical output of the bone conductor for persons with higher thresholds of hearing by bone conduction would yield higher amounts of harmonics. In the case of bone conductor A, at an input frequency of 500 cycles per second a large output of the second harmonic is observed. This can be explained by observing that in the frequency response curve of bone conductor A a peak occurred at 1,000 cycles per second. Due to the nonlinearity of the system the input voltage behaves as if it were composed of a fundamental frequency of 500 cycles per second plus harmonics of 1,000, 1,500 and so on. The 1,000 cycle component produces resonance in the system and gives rise to the large output of 1,000 cycles per second. Similar conditions were found by Waetzmann,[5] who investigated the sound transmission of a rubber membrane asymetrically loaded with mass. The output of harmonics in bone conductors is an undesirable state of affairs because in the given instance the otologist would measure the threshold at 1,000 cycles per second when he thought he was measuring it at 500 cycles per second. Lucae[6] was the first to warn otologists to consider the presence of harmonics in tuning forks when testing bone conduction. He proved the presence of harmonics in the stem of a tuning fork by means of a Herschel-Quincke interference tube.

5. Waetzmann, E.: Ueber erzwungene Schwingungen bei gestörter Superposition, Ann. d. Phys. **62**: 371, 1920.

6. Lucae, A.: Die chronische progressive Schwerhörigkeit, Berlin, Julius Springer, 1907, p. 142.

The higher frequencies do not exhibit much nonlinearity, because nonlinearity depends on large displacements and these do not occur at high frequencies.

The data on bone conductor B indicate that there is not much change of harmonic content of the output when the input voltage is increased from 0.75 volt to about 4 volts.

## COMMENT AND CONCLUSIONS

It is common knowledge among otologists that measurements of bone conduction made with audiometers include a considerable number of stray values. Exact tests under rigid conditions of control were carried out by Greenbaum,

*Data on Nonlinearity*

| Applied Frequency, Cycles per Second | Applied Voltage | 2d Harmonic A* | 2d Harmonic B† | 3d Harmonic A | 3d Harmonic B | 4th Harmonic A | 4th Harmonic B |
|---|---|---|---|---|---|---|---|
| **Bone Conductor 700-A** | | | | | | | |
| 250 | 0.78 | 0 | 100 | −5 | 178 | N‡ | N |
| 500 | 1.2 | −20<br>−16 | 1,000<br>631 | +25 | 5.6 | +18 | 12.6 |
| 1,000 | 1.2 | +30 | 3.2 | N | N | N | N |
| 2,000 | 3.1 | No harmonics | | | | | |
| **Bone Conductor K-1087** | | | | | | | |
| 250 | 4.1 | 31 | 2.8 | 19 | 11.2 | N | N |
| 500 | 3.7 | 32 | 2.5 | 31 | 2.8 | 32 | 2.5 |
| 1,000 | 3.7 | No harmonics | | | | | |
| 2,000 | 0.69 | N | N | 27 | 4.5 | N | N |
| **Bone Conductor K-1087** | | | | | | | |
| 250 | 0.69 | 34 | 2.0 | 13 | 22.4 | 25 | 5.6 |
| 500 | 0.78 | 35 | 1.8 | 30 | 3.2 | N | N |
| 1,000 | 0.78 | No harmonics | | | | | |
| 2,000 | 0.78 | N | N | 27 | 4.5 | N | N |

* Column A gives the decibel difference between the fundamental voltage and the given harmonic measured in the output of the bone conductor. These are read directly on the recorder tape.

† Column B indicates what percentage of the fundamental voltage each harmonic is. The formula for calculating column B is: $B = 10^{(2 - \frac{A}{20})}$

‡ N indicates that no harmonic was found.

Kerridge and Ross [7] on 200 persons with normal hearing, and a wide spread of threshold data was observed. Differences of bone conduction thresholds in one trained observer determined under laboratory conditions on different places of the head have been observed lately by Watson [8] to be as high as 18 decibels. The test has been performed with a high quality bone oscillator of the electrodynamic type. The differences are due to the different load impedances exhibited by skin, connective tissue and muscles covering the skull. The physical conditions under which measurements of bone conduction should be performed have been treated by Bárány [9] and Békésy.[10] The former [11] advocated the use of a high quality bone oscillator of the electrodynamic type many years ago, and Meyer [12] was in agreement with him. Békésy developed a quartz crystal microphone to be placed between the bone oscillator and the head of the patient. The output of the microphone is proportional to the resultant of the acting alternating forces of the bone conductor and the reacting forces of the load impedance as represented by the head and the integument. If calibrated, the instrument of Békésy permits the establishment of the bone conduction threshold in dynes per square centimeter.[13] Figure 5 shows his data.

As to the bone oscillators used at present in clinical audiometry, it can be shown that the frequency response curves vary widely with difference in load impedance and that a small change of the latter has a considerable effect on the frequency response curve. The investigation indicates that the wide variations of threshold values, so well known to the experienced otologist, may be due not only to psychophysiologic differences in different subjects but also to uncontrollable changes of the mechanical performance of commercially available bone oscillators. The investigation also proves that the velocity of the bone oscillator or, what is equivalent, the force applied to the head by the oscillator is a function of the head impedance as well as the internal impedence of the bone oscillator and the voltage applied to it. This fact together with the phenomenon of nonlinearity makes the calibration in meaningful units of the bone conductors used in this work a practical impossibility.

The amount of nonlinear distortion in bone conductor A was rather startling. Watson [14] stated that nonlinearity of the bone conductor decreased the intelligibility of speech transmitted through it to persons with normal hearing. The

7. Greenbaum, A.; Kerridge, P. M. T., and Ross, E. J.: Normal Hearing by Bone Conduction, J. Laryng. & Otol. **54**:88, 1939.

8. Watson, N. A.: Limits of Audition for Bone Conduction, J. Acoust. Soc. America **9**:294, 1938.

9. Bárány, E.: Contribution to Physiology of Bone Conduction, Acta oto-laryng., 1938, supp. 26, p. 1.

10. Békésy, G.: Ueber die Piezoelektrische Messung der absoluten Hörschwelle bei Knochenleitung, Akust. Ztschr. **4**:113, 1939; J. Acoust. Soc. America **11**:259, 1939.

11. Schwarz: Gesichtspunke für den Bau von Knochentelephonen, Ztschr. f. Hals-, Nasen- u. Ohrenh. **27**:434, 1930.

12. Meyer, E.: Physikalische Eigenschaften der elektroakustischen Hörschärfemesser und Hörhilfen, Ztschr. f. Hals-, Nasen- u. Ohrenh. **40**:278, 1936.

13. Békésy, G.: Ueber die Schallausbreitung bei Knochenleitung, Ztschr. f. Hals-, Nasen- u. Ohrenh. **47**:430, 1941.

14. Watson, N. A.: Hearing of Speech by Bone Conduction, J. Acoust. Soc. America **9**:99, 1937.

fact that bone conductors similar in construction to the tested bone conductor A give excellent results as regards intelligibility of speech for persons with middle ear impedance hearing impairment strengthens the theory [15] that persons with such impairment have a high tolerance for nonlinear distortion of speech sounds.

It remains to discuss the value of audiometric threshold curves in clinical practice. It has been shown that no definite values in any measure, decibels or otherwise, can be attributed to the curve arrived at by present methods of clinical audiometry. Should otologists discard the measuring of bone conduction by said methods? We believe that the audiometric bone conduction threshold curve has a clinical value for purposes of establishing a diagnosis. The trend of the curve as well as its general position in the audiographic chart will permit the experienced otologist to utilize it as a symptom of hearing impairment if it has been arrived at by means of an audiometer with which the investigator is familiar. He must realize, however, that such a curve does not represent a measurement of the force applied. It should be used as a rule of thumb based on clinical experience only, similar to the rules of thumb known as Weber, Rinne and Schwabach tests.

The investigation presented exhibits some of the sources of the errors which occur in present methods of audiometric testing of hearing by bone conduction. They are in the bone conductor itself and not in a particular manner of testing or in psychologic factors.

133 East Fifty-Eighth Street.

15. Halsted, T. H., and Grossman, F. M.: Modern Aspects of the Hearing Aid Problem, New York State J. Med. **42**:1944, 1942.

# FISSURAL CYSTS

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A neglected but interesting topic of American rhinology is that of a cyst which encroaches on the nasal vestibule or appears on the anterior portion of the hard palate. American rhinologic literature [1] is relatively barren of references to this subject, while references are rather plentiful in the European literature.[2] Some attention is given to this condition in American dental literature [3] and in certain American texts [4] on diseases of the jaws. The older textbooks of rhinology ignore the entity, while the latest texts [5] fail to mention it or give only a few sentences of information concerning it. It seems timely to emphasize a clinical finding that every physician should be able to recognize and understand.

Fissural cysts may develop at the sites of embryonal fusion of the various processes which unite to form the jaws. (Less favored are the theories of origin that relate these cysts to the nasolacrimal duct, to Jacobson's organ or to the closure of the duct of a mucous gland.) The cysts have their origin in epithelial cells which may be enclaved there. Such cells have been demonstrated in the mesenchyme in these areas of fusion.

Two types of fissural cysts are distingushed. One type results from fusion of the premaxilla and the maxilla, i. e., a cyst of the facial cleft, while the second type results from the fusion of the palatal processes, i. e., a cyst of the incisive canal.

## CYST OF THE FACIAL CLEFT

According to Thoma, the most common cyst of the facial cleft is the nasoalveolar, which is formed in the lateral nasal cleft at the site of union of the premaxilla and the maxilla, which in turn are formed from the globular processes and the maxillary process of the embryo. This cyst arises commonly on the bone below the piriform aperture and enlarges superiorly and anteriorly. (Its bilateral occurrence has been described.) This results in the clinical symptoms of a fluctuant tumor which elevates the floor of the nasal vestibule, obliterates the nasofacial fold if sufficiently large, and extends or fills the superior labial tissues. When large, the nasoalveolar cyst produces asymmetry and distortion of the features. The cyst elevates the anterior tip of the inferior turbinate, and the encroachment on the nasal breathing space may constitute the patient's chief complaint.

A characteristic feature is the fact that this cyst rests in a shallow depression on the bone surface instead of developing from within the bone as in the case of the radicular or the dentigerous cyst, which may appear in the same area. The lining membrane varies and may be ciliated, while goblet cells are usually plentiful. The contents are mucoid and may contain cholesterol. The cyst is more or less adherent to the surrounding tissue, depending on previous trauma, attempts at incision or aspiration, or other manipulations. Some slight local discomfort may be present because of pressure on a nerve. The cyst occurs most frequently in women. It may readily be removed through a medially placed Caldwell-Luc incision.

Thoma stated that the cyst of the facial cleft also arises at the site where the maxillary and the globular process and the middle and palatal nasal processes fuse and obliterate the nasooptic furrow. Still another site is the alveopalatine cleft.

## CYST OF THE INCISIVE CANAL (CYST OF THE NASOPALATINE DUCT)

After the fusion of the palatine processes of the maxilla in the human embryo, a communication is left between the oral and nasal cavities on each side of the palatine papilla. In the adult this nasopalatine canal or duct occasionally remains patent, but generally either the nasal or the oral end is closed, forming a cul-de-sac. The nasal orifice of the duct lies at

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1. Laszlo, A. F.: So-Called Mucoid Cysts of the Nose, Arch. Otolaryng. **21**:41 (Jan.) 1935. Sooy, F. A.: Nasoalveolar Cysts, Laryngoscope **54**:18 (Jan.) 1944.

2. Huizinga, E.: On Cysts Near the Nose Entrance, Acta oto-laryng. **8**:505, 1925.

3. (*a*) Meyer, A. W.: Median Anterior Maxillary Cysts, J. Am. Dent. A. **18**:1851 (Oct.) 1931. (*b*) Schroff, J.: Unusual Cysts of the Maxilla, Dent. Items of Interest **51**:107 (Feb.) 1929.

4. Thoma, K. H.: Clinical Pathology of the Jaws, Springfield, Ill., Charles C Thomas, Publisher, 1934, p. 262.

5. Ballenger, W. L., and Ballenger, H. C.: Diseases of the Nose, Throat and Ear, Philadelphia, Lea & Febiger, 1943, p. 495.

the side of the septum about 2 cm. posterior to the anterior part of the naris on the nasal floor in relation to the torus nasopalatinus. The oral openings consist of two small slits, one on each side of the palatine papilla which overlies the incisive foramen. The nasopalatine duct is not to be confused with the vomeronasal organ of Jacobson, which is a nearby but separate structure.

A cyst of the incisive canal may have one of several origins. It may result from the activity of a cell rest in the incisive canal. Another cause is said by Schroff [3b] to be inflammation of the palatine papilla from the trauma of mastication or from dental or nasal sources. This inflammation of the papilla is thought to involve the nasopalatine duct and to eventuate in the formation of a cyst by closure of the opening of the duct.

The usual clinical history is that of a swelling which appears in the midline on the anterior portion of the hard palate. Owing to its location, it is apt to become irritated during mastication. If it is much irritated, a localized discomfort extending into the nose and the eyes may result. Prolonged or severe irritation may be followed by inflammation and abscess formation.

Roentgenograms [6] of the area of the incisive canal may be difficult of interpretation. In the differential diagnosis of midline shadows in this region, such conditions as large incisive foramen, cyst of the incisive canal and cyst of dental origin must be considered.

## REPORT OF CASES

CASE 1.—Mrs. R. S., a Negro woman aged 52, consulted me on Jan. 27, 1944 because of inability to breathe through her left nostril, the vestibule of which was occupied and distended by a tumor mass. She stated that this mass was first noticed about a year previously and that because it had increased in size it was "cut under her upper lip" by her family physician in December 1943. The mass thereupon became slightly smaller, but soon it grew even larger than before and was slightly painful whereas previously it was painless.

There was evident asymmetry of the face in that the left naris was distended with a globular tumor. The left nasofacial fold was obliterated, and the left upper lip was somewhat protruded. The tumor snugly filled the nasal vestibule and was soft and fluctuant, though not inflamed. By depressing it firmly from above one observed that it was limited to the vestibule and the anterior portion of the inferior meatus. The anterior tip of the inferior turbinate was thinned and displaced superiorly against the nasal septum.

The superior alveolus was normal (except that the patient was edentulous), but the globular fluctuant mass was palpable under the lip and just inferior to the piriform aperture. The cystic mass could be moved readily by pressure over the mass in the nasal vestibule and counterpressure beneath the upper lip. It appeared to be about 4 cm. in diameter. The adjacent canine fossa was normal to palpation and the sinuses transilluminated clearly. The remainder of the local and general examination gave negative results except for some cardiac irregularity and hypertension (blood pressure 250 systolic and 150 diastolic). The Wassermann test was negative. The patient was referred to Dr. H. L. Farmer for roentgen examination, and the following report was submitted:

"Examination of the nose and the bony structures adjacent to the left nasal vestibule shows thinning of the medial bony wall of the left antrum. One of the views shows a sharply defined concavity in the lateral bony wall of the nasal cavity. The observations suggest absorption of bone under pressure. There is no evidence of any formation of a cyst in the alveolus. The left nasal cavity is encroached on by a soft tissue mass in the vestibule."

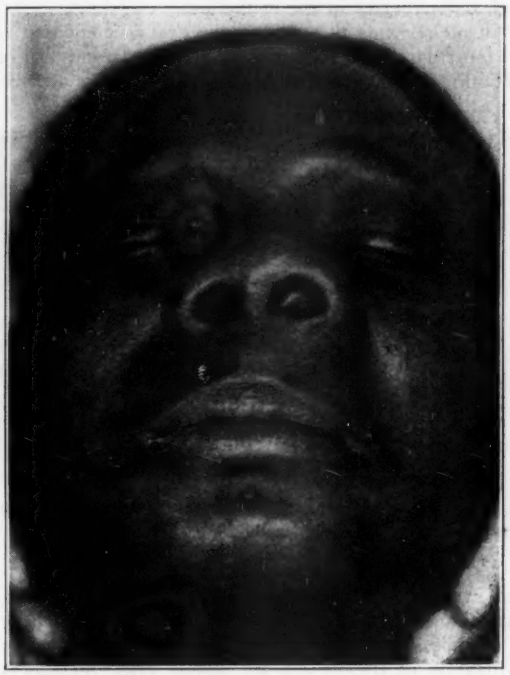

Fig. 1 (case 1).—Distortion of the ala of the left naris and fulness of the upper portion of the left upper lip caused by a nasoalveolar cyst.

On February 29, with the region under anesthesia induced by infiltration with procaine hydrochloride, the cystic mass was removed through a sublabial approach. An artery and a nerve coursing transversely were freed from the cyst wall. The cyst was adherent and was accidentally ruptured when being separated from the floor of the nasal vestibule. Here a small rent was made in the nasal mucous membrane, owing to the thinness of the intervening tissue. The cyst was most firmly attached to the bone in a small shallow depression just inferior to the piriform aperture. The content of the cyst was thick, brownish and mucoid; it was not otherwise examined. Drs. R. Dominguez and A. Craine, of

6. Pancoast, H. K.; Pendergrass, E. P., and Schaeffer, J. P.: Head and Neck in Roentgen Diagnosis, Springfield, Ill., Charles C Thomas, Publisher, 1940, p. 280. Ennis, L. M.: Dental Roentgenology, Philadelphia, Lea & Febiger, 1939, p. 210.

the department of pathology of St. Luke's Hospital, presented the following histologic report:

"The epithelium is stratified and varies from two to about ten cells in thickness. Where the epithelium is thin, the cells are flattened, and where it is thicker, they tend to be polygonal. The cells are small; the nuclei are small and round or oval, and have finely divided chromatin material. In some places the deepest layer forms a distinct regular basal row of cells, and in other places a distinct regular superficial layer is seen. However, for the most part the cell layers are irregular and not differentiated. Scattered irregularly through the epithelium there are large cells resembling goblet cells. In sections stained by the mucicarmine method these cells are seen to be filled with material which takes a positive stain for mucin. No cilia are seen on the epithelial cells. This epithelium more closely resembles the epithelium of the conjunctiva than that of the nose. In some areas there are a few polymorphonuclear leukocytes in the epithelium.

"In all sections the wall of the cyst is composed for the most part of dense fibrous connective tissue. In one section a few bundles of striated muscle fibers are seen, and in several sections there is a small amount of adipose tissue. All sections show a rather marked degree of chronic inflammation characterized by a marked focal infiltration of the stroma by plasma cells, lymphocytes and a few polymorphonuclear leukocytes."

Healing and recovery were uneventful.

The diagnosis was nasoalveolar cyst.

CASE 2.—Mr. H. R., a white man aged 47, was referred to me on March 4, 1943 by Dr. H. H. Bromley because of a nasal fracture sustained two days previously and because of a painful swelling in the roof of the mouth of one week's duration, the two conditions being merely coincidental. Examination revealed a fractured nose and a firm, tender, inflamed globular swelling about 2.5 cm. in diameter in the midline of the hard palate posterior to the alveolus, together with some swelling of the upper lip. The patient was edentulous in the upper jaw and wore a denture.

It was planned to reduce the nasal fracture and incise the probable abscess of the hard palate. When the patient was seen in the operating room on the following morning, it was found that the abscess had ruptured spontaneously. In order to provide more adequate drainage, the swelling was incised and a small amount of bloody pus evacuated.

The possibility that this swelling could be an infected cyst of the incisive canal was not thought of at this time; rather it was associated with a possible infection of the bone of the hard palate. With this in mind, the floor of the swelling was carefully palpated with a probe to detect any bare rough bone, but none was found. A request for roentgen examination at this time was misunderstood and only the upper alveolus was reported on; this was normal except for an uninfected retained small tooth fragment. The nasal fracture having been reduced and the swelling of the hard palate having subsided, the patient was discharged.

Special interest in this subject was aroused by my experience with the nasoalveolar cyst, and because of this the roentgenograms of patient H. R. were reviewed. Surprisingly enough, an oval area of decreased density was observed in the midline of the hard palate anteriorly. Since these films were not taken in such a position as to rule out a possible large incisive foramen, the patient was asked to return, and additional roentgenograms were taken on April 8. In summarizing these roentgen findings Dr. R. J. May, the roentgenologist, stated that there was ". . . a somewhat oval area of decreased density about 1 cm. broad and somewhat longer than it is wide in the anterior midportion of the hard palate. This defect is smooth and has possibly been present for considerable time. It seems to resemble a benign cystlike area in the superior maxilla."

Fig. 2 (case 2).—Roentgenograms showing median and oblique views of the defect in the hard palate due to the presence of a cyst of the incisive canal.

Examination of the hard palate at the time of writing reveals only a slight thickening of the soft tissue over the region of the incisive foramen. The patient states that since March 1943 he has had two recurrences of a tender swelling in the anterior portion of the hard palate but that in each instance the swelling spontaneously disappeared after, he thought, discharging into the mouth.

In a consideration of the clinical course together with the roentgen evidence it seems that the symptoms in this patient were due to recurring infection of a cyst of the incisive canal.

The diagnosis was infected cyst of the incisive canal.

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# NEURINOMA OF THE FACIAL NERVE

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Neurinoma of the facial nerve has only recently been reported in the American literature. The tumor has also been known by such names as "perineurial fibroblastoma," "neurilemmoma," "peripheral glioma," "schwannoglioma" and "schwannoma."

This report, with the presentation of a case, is being given because of the rarity of the tumor and because it demonstrates the possibility of making a preoperative diagnosis.

In 1935 Altmann [1] presented 4 cases of neurinoma of the descending portion of the facial nerve; then, in 1937, he reported 1 more case.[2] In both his reports he demonstrated that the tumor presents a definite clinical entity and published the first comprehensive discussion of the differential diagnosis. He dealt with far progressed stages of the condition and the important diseases entering into the differential diagnosis. These are chronic otitis media with polyp formation, proliferative tuberculosis of the middle ear and carcinoma of the middle ear. Altmann [2] stated that with neurinoma of the facial nerve the persistence of facial paralysis over a long period without remission and without a history of a discharge from the middle ear preceding the paralysis favors the diagnosis of tumor of the nerve. A well pneumatized mastoid process helps to make the diagnosis, while one in which pneumatization is impeded speaks to a certain extent for chronic otitis media but does not exclude the tumor. With tumor of the nerve there may be erosion of the posterior inferior wall of the external bony canal, of the floor of the tympanic cavity or of the lateral attic wall. Chronic otitis media may coexist with neurinoma, and this must always be considered. As for tuberculosis of the middle ear, good pneumatization of the mastoid process and the presence or the absence of lesions elsewhere help. Carcinoma of the middle ear is seen to develop on chronic otitis media; the facial paralysis is a late rather than an early symptom, and there is marked pain, which is against a diagnosis of neurogenic tumor.

In 1943 Altmann [3] reported 3 cases of granular cell myoblastoma of the external auditory meatus and showed this type of tumor to be very similar from the point of view of symptomatology to neurinoma of the facial nerve, so that the making of a differential diagnosis may even be impossible. However, clinically it was noted that in myoblastoma profuse bleeding occurred with trauma (biopsy, operation), while in neurinoma such bleeding was not observed.

In the case presented in this paper the lack of profuse bleeding during the procedure of biopsy was what favored the diagnosis of neurinoma rather than that of granular cell myoblastoma.

## THE FIBERS OF THE FACIAL NERVE

The observation often has been made that otogenic facial paralysis is not always complete and that not all muscles supplied by the peripheral branches of the nerve are involved to the same degree.

Hofmann [4] in 1924 studied the course of the individual branches of the facial nerve in the stem portion. In over 20 specimens he demonstrated that the stem of the facial nerve is divided into main bundles, usually two, a superior and an inferior branch, occasionally more. Throughout its course peripheral to the geniculate ganglion and even proximal to this the stem represents individual muscle innervations. In the horizontal course of the nerve (fig. 1) the superior branch is lateral while the inferior branch is medial. The chorda tympani nerve is most lateral in this position, its relationship to the superior branch being the closer one. A similar relationship except for the chorda tympani nerve is maintained in the internal auditory meatus. As illustrated in figure 1, taken from Hofmann's [4] paper, the facial nerve rotates in its course

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1. Altmann, F.: Ueber neurogene Tumoren des absteigenden Facialisteiles, Monatschr. f. Ohrenh. **69**: 1032-1048, 1935.

2. Altmann, F.: Zur Kenntnis der Tumoren des absteigenden Facialisteiles, Monatschr. f. Ohrenh. **71**: 1287-1292, 1937.

3. Altmann, F.: Granular Cell Myoblastomas of the External Auditory Meatus, Laryngoscope **53**:195-202, 1943.

4. Hofmann, L.: Der Faserverlauf im Nervus facialis, Ztschr. f. Hals-, Nasen- u. Ohrenh. **10**:86-89, 1924.

through the fallopian canal, but nevertheless the superior and inferior branches maintain a definite relationship to each other.

## REPORT OF A CASE

H. K., a Jewish white man, aged 41, was first seen by the admitting physician of the Presbyterian Hospital in New York on Jan. 9, 1944. He presented a history of a progressive right-sided facial paralysis of over five months' duration, becoming complete three days before admission, and slight pain in the right ear. Otoscopic examination revealed the drum membrane to be pinkish gray and bulging slightly in the posterior inferior quadrant. There was no mass protruding in the canal, and there was no discharge. The rectal temperature was 99.8 F. Myringotomy was done, and the patient was admitted to the ward.

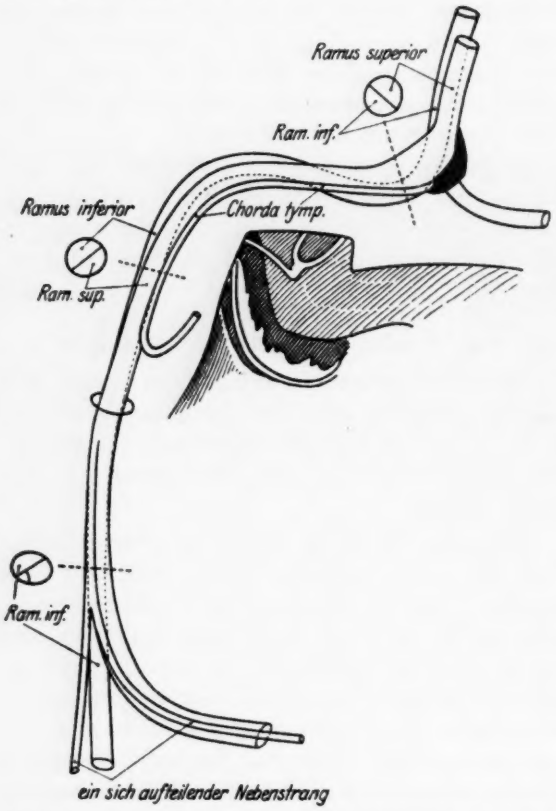


Fig. 1 (after Hofmann [4]).—The relationships of the chorda tympani nerve and the superior and inferior branches of the facial nerve to each other in the facial canal.

In the ward a more detailed history was taken. For a period of ten years the patient had noted that hearing in the right ear had become progressively worse. Inflations of the eustachian tube produced no improvement. Five months previous to admission he noted twitching of the right lower eyelid and infraorbital region and was told that a tic was developing. Two months after this observation he was unable to close his right eye, and then, three days before admission, complete right facial paralysis and slight pain in the right ear developed. He did not complain of vertigo or tinnitus but had a feeling of fulness in the ear. He had just recovered from "bronchopneumonia." The past and family histories were irrelevant.

Physical examination revealed a well developed, well nourished white man with complete right-sided facial paralysis. There was no spontaneous nystagmus; the pupils were round, regular and equal and responded to light and in accommodation. There was a loose blood clot in the right aural canal, removal of which revealed a small reddish mass extruding through the site of the myringotomy incision in the posterior inferior quadrant. Little fresh bleeding occurred. Grossly there was no purulent discharge. Hearing in this ear was poor; in the Weber test the sound was lateralized to the right; the Rinne test showed bone conduction to be better than air conduction. The left ear was normal. Taste for all qualities was absent on the anterior two thirds of the right side of the tongue. The remainder of the physical examination gave essentially normal results. The vestibular (rotation) test indicated that the labyrinth was intact.

The audiogram showed for the right ear losses of between 40 and 50 decibels in all frequencies for hearing by air conduction, with hearing by bone conduction normal, and for the left ear normal hearing by both air and bone conduction.

Laboratory studies gave results as follows: Kline reaction of the blood, negative; red blood cell count, 4,500,000; white blood cell count, 11,500; urine, normal.

Roentgenograms of the mastoid processes showed extensive pneumatization with haziness of the cells.

The following day the patient's right ear was examined again. Only a small amount of blood was present, and when this was wiped away, the reddish mass protruding through the posterior inferior quadrant of the drum membrane was seen again. It did not appear like fibrin, and little free bleeding occurred. It was at this time that the impression of a tumor involving the facial nerve was made. It seemed more likely to be a neurinoma than a granular cell myoblastoma since bleeding was slight. Biopsy of the tissue protruding through the myringotomy opening was done, and the next day a second specimen was taken from the same place for microscopic examination.

Histologic examination (by Dr. A. P. Stout, of the department of surgical pathology) of several small fragments of tissue showed in some areas a tissue consisting of parallel strands of spindle-shaped cells with elongated vesicular nuclei. The nuclei were often arranged in palisades. Between the strands of cells there were areas of edema and of recent hemorrhage. The diagnosis was neurinoma of the external aural canal, following neurinoma of the middle ear.

It has been generally noted in reported cases of neurinoma of the facial nerve that radium and roentgen therapy are not efficacious. Though surgical intervention may not effect complete cure, the large cavity present following radical mastoidectomy allows free space into which the tumor may extend if further growth occurs. Therefore, on Jan. 14, 1944, with intravenous administration of pentothal sodium as the means of inducing anesthesia, the usual postauricular approach to the mastoid process was made, and thus the gross pathologic change was demonstrated. The mastoid process was large and well pneumatized except for the retrolabyrinthine region; the mucosa of the cells was slightly edematous. A neoplastic mass was seen to fill the middle ear, extending from between the superior semicircular canal and the opening of the eustachian tube along the anterior border of the petrous pyramid; it had eroded the bone of the middle fossa so that the dura was visible. The latter, however, was normal in color, and the tumor mass was not attached to it. The tumor involved the horizontal portion of the facial nerve from the region apparently external to the genicu-

late ganglion to that portion where it curves underneath the external semicircular canal. The tumor could not be isolated from the nerve. The growth was removed as completely as possible and the remainder of the operation performed as in a radical mastoidectomy. The middle ear and mastoid cavities were packed with iodoform gauze, and the postauricular wound was closed with metal skin clips.

Postoperative care consisted of treating with sulfadiazine as a prophylactic measure and routine dressing as in the case of a radical mastoidectomy wound. The recovery was uneventful. To date the complete facial paralysis has remained unchanged.

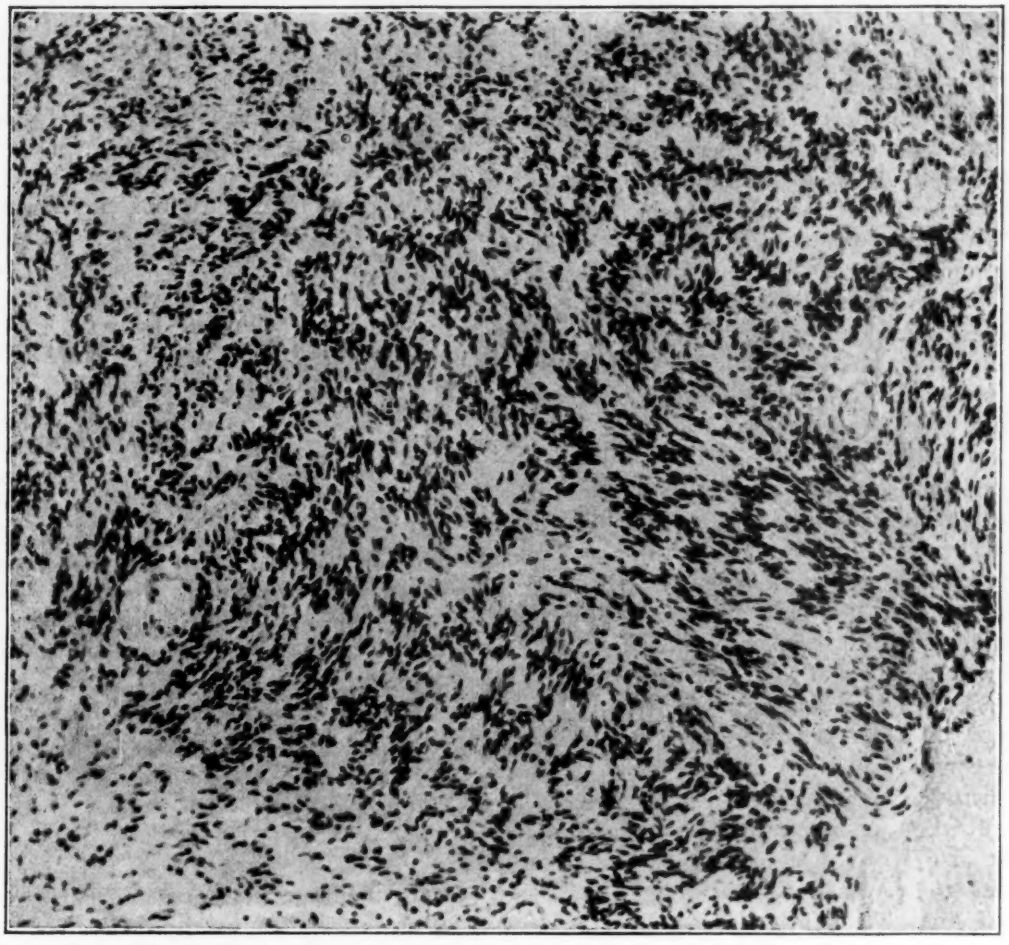

Fig. 2.—Operative specimen showing palisading and whorl formation of the nuclei.

Microscopic examination of the operative specimen (Dr. A. P. Stout) showed (fig. 2) that the tissue was composed of great numbers of elongated cells with poorly outlined cytoplasm and oval-shaped nuclei. These cells were arranged in strands that often made whorls. Often the nuclei were arranged side by side in palisades. There were areas in which the tissue was quite compact and other areas in which the cells were separated by a loose fibrillar stroma. In one of the sections there were irregular cystlike cavities containing an eosinophilic material and some red blood cells. The tumor cells were often arranged radially around the cavities. The tumor cells were fairly uniform in size and shape and did not show an increase in mitotic activity.

The postoperative diagnosis was typical neurinoma of the middle ear of a benign type.

## COMMENT

The case presented is noteworthy in several respects. The neurinoma was in an early stage; therefore an analysis of the early symptoms becomes possible. The first symptom was conduction deafness, which was slowly progressive over a period of ten years, whereas from the onset of twitching of the infraorbital muscles to complete facial paralysis only five months elapsed. Similarly, in Greifenstein's [5] case, in which a neurinoma of the facial nerve was found accidentally at autopsy, the first and only clinical symptom relative to the ear was slight impairment of hearing, with no facial paralysis preceding it. The slight pain in the ear and the prolapse of the tumor through the myringotomy incision in the present case were no doubt due to the erosion through the tympanic membrane which was imminent. Taste was disturbed

5. Greifenstein, A.: Zur Kenntnis der isolierten Facialisneurinome, Arch. f. Ohren-, Nasen- u. Kehlkopfh. **142**:50-53, 1936.

owing to involvement of the chorda tympani nerve.

This type of tumor arises from the nerve sheath and is expansive in its growth, following the line of least resistance. In the first and third portions of the fallopian canal the bony walls are more resistant to expansion than in the second portion; hence the onset of paralysis may be earlier with a tumor in either of the former locations than with one in the latter location. If the tumor should arise in the internal auditory meatus, facial paralysis would occur first, followed by a nerve type of deafness if the auditory nerve should become involved. (This has not been seen clinically.) If the tumor occurs in the third portion of the facial nerve, paralysis occurs together with the appearance of a polyp in the innermost portion of the posterior-inferior wall of the external canal, with intact drum membrane and middle ear (Schmidt, cited by Altmann [1]). This may or may not be followed by the conduction type of deafness, depending on the extent of growth and the invasion of the middle ear. However, if the tumor arises in the second portion of the facial nerve, where resistance is minimal owing to the space of the middle ear cavity, deafness of varying degrees and types occurs as the first presenting symptom, depending on whether the disturbance affects the movements of the ossicles or leads to fixation of the footplate of the stapes or to occlusion of the round window. A tumor originating from the superior branch in this part of the facial nerve would be more likely to give rise to a disturbance of hearing before paralysis than a tumor arising from the inferior branch, which is here medial. Since paralysis has occurred before deafness, e. g., in Roberts' [6] and Rejto's [7] cases, the latter region may have been the site of origin of the tumors. Taste in the anterior two thirds of the tongue on the same side may be disturbed, depending on the involvement of the chorda tympani nerve. Most likely the patient himself would not note this symptom, but if it is present, it is demonstrable by the physician.

Labyrinthine disturbances may occur in cases in which the tumor has progressed further, and with secondary infection the same complications may arise as are seen in disease of the middle ear (Altmann [1]; Roberts [6]; Williams and Pastore [8]).

The relationship of the tumor to the surrounding structures and the degree to which these structures are disturbed give the outline of the symptoms and signs. On analyzing the order of appearance of the symptoms and signs it may be said that the tumor described in this paper had its origin from the superior branch of the horizontal portion of the stem of the facial nerve, that it involved the chorda tympani nerve laterally, then filled the middle ear and produced conduction deafness and that later it damaged the facial nerve fibers, with progressive facial paralysis resulting. Once the impression of a neurinoma of the facial nerve or of a granular cell myoblastoma was made, the most significant sign for the differential diagnosis became the lack of profuse bleeding at biopsy.

In conclusion, the clinical picture of neurinoma originating in the horizontal portion of the facial nerve may be characterized in its early stage by progressive impairment of hearing, slowly increasing facial paralysis without preceding infection of the middle ear, disturbance in taste in the anterior two thirds of the tongue on the same side and absence of pain in the ear. In a somewhat later stage there may be tumor prolapsing through the drum membrane, and if there is, lack of profuse bleeding during biopsy is significant.

If secondary infection of the middle ear occurs, the complications, the treatment, the course and the prognosis are similar to those of any infection of the middle ear.

## SUMMARY

A neurinoma of the horizontal portion of the facial nerve was diagnosed preoperatively in the case reported. The order of symptoms and signs described will not only suggest the diagnosis preoperatively in similar cases but help localize the origin of the tumor in one of three portions of the facial nerve that may be involved.

108 Oak Street.

6. Roberts, G. J.: Neurinoma of the Facial Nerve in the Middle Ear and Mastoid, Arch. Otolaryng. **37**: 63-73 (Jan.) 1943.

7. Rejto, A.: Fall eines vom Gesichtsnerven ausgehenden Tumores, Monatschr. f. Ohrenh. **73**:615-618, 1939.

8. Williams, H. L., and Pastore, P. N.: Neurofibroma of the Facial Nerve in the Facial Canal with Destruction of the Labyrinth and Mastoid Process, Arch. Otolaryng. **29**:977-981 (June) 1939.

# Case Reports

## REMOVAL OF A FRONTAL OSTEOMA AND CORRECTION OF THE DEFECT WITH A TANTALUM IMPLANT

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In February 1943, a 22 year old white man, while on active duty in North Africa, noticed a slight bulging of his right eye. This was associated with intermittent mild frontal headaches and what he thought was a failing of vision in the right eye. At this time he experienced an infection of the upper respiratory tract; the right upper and lower eyelids became markedly edematous, and the anterior margin of the right frontal sinus was quite tender. This attack subsided rather promptly with conservative local intranasal treatment. Subsequent examinations revealed the eye to be still proptosed and the condition gradually progressing. There was no history of trauma or of chronic sinus disease.

Fig. 1.—Preoperative views of the patient with osteoma of the right frontal sinus.

Examination at the hospital at which I am stationed showed the vision in both eyes to be 20/20, and there was ability to read Jaeger's test type 1. The fundi were normal. The pupils were equal and circular and reacted to light and accommodation. Although muscle balance was found to be within normal limits, the patient complained of intermittent diplopia. There were three old scars on the right cornea. The visual fields and the tension in both eyes were normal. The proptosis of the left eye was 16 mm. and that of the right eye 23 mm. The right upper eyelid was edematous and contained several superficial dilated tortuous veins. Further examination revealed a moderate prominence of the margin and of the anterior plate of the right frontal sinus and a marked bulging of the floor into the orbit. These areas were slightly tender to firm pressure. The eye was not red and did not appear inflamed. The airway in the nasal cavity was adequate. The mucous membrane was healthy, and there was no free pus. The middle meatus on the right side presented nothing unusual.

Roentgenograms revealed an osteoma in the right frontal sinus. The osteoma presented its most dense composition along its superior and lateral margins. The medial and inferior margins were of a diploic structure.

On July 26, with the patient under intratracheal anesthesia, an incision was made parallel to and just above the right eyebrow, down to the cortex of the frontal bone. The soft tissues appeared to be more vascular than usual, and after separation of the periosteum the anterior plate was found to be softened and hyperemic. The floor of the sinus was completely obliterated by a large bulging lobulated osteoma which pressed against the superior part of the globe. As the cortex of the frontal plate was being removed, its attachment to the osteoma was discovered to be in the medial inferior portion of the plate. The new growth

Read at the meeting of the Philadelphia College of Physicians, Jan. 15, 1944.

Fig. 2.—The appearance of the patient after removal of the osteoma.

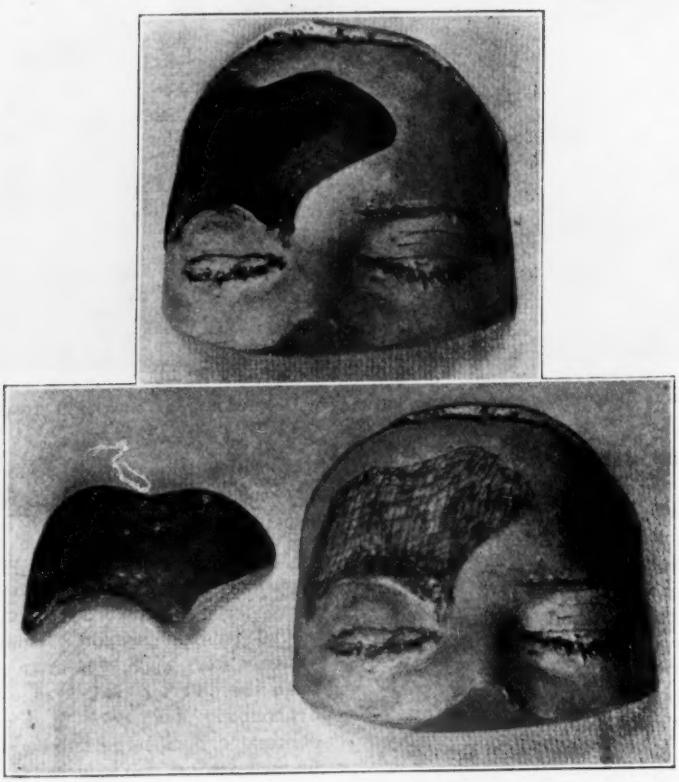

Fig. 3.—The molded tantalum implant on a dental stone cast.

completely filled the sinus and had expanded it by pressure until the sinus assumed the form of the osteoma. The tumor was removed in two portions. Grossly one observed that the medial inferior portion of it was made up of a cancellous type of bone, which bled easily and freely and was brittle. The margin of the osteoma, especially the lateral superior margin, was of an eburnated quality, with localized lobulations advancing beyond the main mass. This portion was essentially avascular. It was perfectly smooth, white and extremely hard and was covered with a thin layer of connective tissue and respiratory epithelium. It separated freely from the walls of the sinus, which also presented a thin layer of connective tissue and respiratory epithelium. When the osteoma was being removed from the posterior portion of the sinus, an inadvertent tear in the dura occurred, which was approximately 3 mm. long. The posterior sinus plate had been eroded in an area about the size of a half dollar in the central part of the sinus as a result of the pressure of the osteoma. The dura at this level was extremely thin and fragile and was apparently adherent to the posterior surface of the new growth. The medial extension of the osteoma passed over into the left frontal sinus, beyond the intervening septum and the medial loculation of this sinus was removed. In the region of the right nasofrontal duct opening on the floor of the sinus, the mucous membrane was moderately thickened, but there was no exudate of any type. The osteoma was the size of a goose egg, was localized, possessed no infiltrative characteristics and came away without great force. Histologic examination of the tumor revealed well formed bony trabeculae of varying size with a normally developed structural pattern. The operative cavity was tidied up. The small dural tear was covered with a segment of frontal muscle. The nasofrontal duct was plugged with a segment of frontal muscle, and this was cauterized in the duct. Sulfanilamide was sparingly applied to the cavity, and the latter was closed with through and through silk sutures, a small rubber drain being left at the lateral angle of the wound. The highest postoperative temperature was 99.4 F. The wound healed by primary union, and the convalescence was normal. Diplopia gradually disappeared completely. Pulsations of the right frontal lobe were in evidence.

Fig. 4.—The postoperative result two weeks after surgical correction of the operative defect.

Fig. 5.—The patient, June 3, 1944.

On September 14, a large right frontal flap was made, as much of the incision as possible being kept within the hair line. The dura was hypertrophied, completely intact and of good color. The periosteum

was adherent to it, and separation was tedious. As the eyebrow on the right side was approached, the scar in its innermost dimension was quite adherent to the dura, and at this point the dissection was sharp and slightly elevated over the dura. Bleeding was controlled with a Bové unit, and the previously prepared tantalum plate was placed in position. The edges of the bone about it were lowered in order to secure a smooth approximation and to facilitate the fitting. Three holes were made in the bone—one at the nasal margin, one at the extreme lateral margin and one superiorly. The thickness of the plate was $\frac{1}{3.000}$ of an inch (0.083 mm.), and it was fixed in position with tantalum wire. The plate did not rest against the optic globe or against the dura. However, there was considerable dead space between the plate and the dura. The region of the nasofrontal duct was examined carefully, and although there appeared to be sinus mucous membrane in this area, the opening of the duct could not be discovered with a probe. In addition, no blood escaped into the nose. The flap was reapproximated without drainage. A moderately snug pressure bandage was applied. The wound healed by primary union with little reaction, and the convalescence was uneventful.

A communication from the patient in February 1944 revealed that he had been completely free of symptoms in the interim.

## COMMENT

Because it was not known at the time of the first operation that a tantalum implant would eventually be employed to correct the defect, two incisions were made. The entire technic may be carried out by using a frontal flap. If the sinus should prove completely free of infection, it would be advisable to implant the tantalum at the operation for removal of the osteoma. Tantalum is a satisfactory material for reconstruction. It is malleable and sufficiently strong and is tolerated well by the tissues.

# THROMBOSIS OF THE CAVERNOUS SINUS

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This case of thrombosis of the cavernous sinus is being reported because the patient survived for three months and the clinical diagnosis was proved correct at necropsy.

## REPORT OF A CASE

D. T., a 16 year old boy, was well until Nov. 12, 1942. On that day he picked a furuncle on the left side of his nose, and on the following day the left eye became swollen, and the swelling and proptosis progressively increased. The right eye first became swollen on November 17, and during this five day period the boy experienced numerous chills, followed by high temperature. During these five days he was given 15 Gm. of sulfathiazole by the family physician. He complained of sharp pains in the left side of his chest on inspiration for two days preceding admission to the hospital. He was admitted to the University of Kansas Hospitals on November 18.

The patient Nov. 19 (left) and Dec. 6 (right), 1942.

On admission the patient was found to be a well developed white boy acutely ill but completely rational. There were swelling and proptosis of both eyes, more marked on the left, together with considerable bilateral conjunctival edema. There was much swelling around the previously traumatized furuncle. The ocular muscles on the left revealed complete and those on the right partial paralysis. Both pupils were dilated and did not react to light. The retinal veins were dilated, and there was tenderness on pressure over both emissary veins. There was no discharge or swelling of the mucous membrane in either nostril. A friction rub and fine crepitant rales were heard over the left side of the chest. A blood culture showed a growth of hemolytic Staphylococcus aureus.

The patient was treated with large doses of sulfathiazole, given both orally and intravenously. He was given 100 cc. of a 5 per cent solution of sodium sulfathiazole intravenously every day for twelve days and 1 Gm. of sulfathiazole orally every three hours—a total of 195 grains (12.5 Gm.) daily. He also received daily 40 cc. of heparin, which was given intravenously, as well as numerous small blood transfusions.

During the first twelve days the patient's temperature ranged from 100 to 105 F., and the white blood cell count varied from 18,000 to 44,000 per cubic millimeter; at this time he was frequently irrational. On November 24 an abscess of the left orbit was incised, with profuse purulent drainage. Following this, he slowly improved and was dismissed on Jan. 1, 1943, free of complaints except for an occasional slight headache occurring after reading. He had been given sulfonamide compounds during his entire hospitalization; during this period of seven weeks he was given a total of more than 7,000 grains (453.5 Gm.) of sulfathiazole and sulfadiazine. Occasional slight nausea was the only sign of toxicity, but the intake of fluids was kept at a high level.

On February 2 the patient was readmitted to the hospital. He gave a history of a cold occurring two weeks previously, following a hunting trip and complained of severe frontal headaches, marked irritability, projectile vomiting, nocturia and diplopia. Babinski and Kernig signs were present bilaterally, with rigidity of the neck and there was a choked optic disk on the left.

Roentgen examination revealed localized osteomyelitis of the left side of the frontal bone with pansinusitis on

the left. The spinal fluid contained 6,000 pus cells per cubic millimeter, with no organisms. The spinal fluid pressure was elevated, and the blood cultures at this time showed no bacterial growth. On February 8 the osteomyelitic bone was removed, and on February 11 the left frontal lobe of the cerebrum was probed for an abscess, but none was found. The patient was comatose at this time and died on February 13. During this period of hospitalization he daily received intravenously 100 cc. of a 5 per cent solution of sodium sulfadiazine.

*Necropsy.*—The following conditions were observed at necropsy: acute and chronic perisinusitis (cavernous sinus); chronic basilar meningitis; old healed pulmonary infarct; organizing pneumonia; abscess of the lung; acute myocarditis; acute dilatation of the heart; acute splenitis; acute toxic hepatitis; subacute glomerular nephritis; emaciation.

## COMMENT

The course of this patient's disease was extremely unusual, presenting many points for comment and controversy.

Clinically, the patient presented all of the classic signs and symptoms of thrombosis of the cavernous sinus. They were:

(*a*) an etiologic focus in the pimple on his nose that had been traumatized; (*b*) swelling and proptosis of the left eye, soon followed by similar involvement of the right eye; (*c*) bilateral conjunctival edema; (*d*) dilatation of retinal veins; (*e*) positive blood culture for hemolytic Staphylococcus aureus; (*f*) complete paralysis of the ocular muscles on the left, with partial paralysis of those on the right; (*g*) tenderness over both emissary veins; (*h*) cells in the spinal fluid, with definite elevation of the spinal fluid pressure.

The only unusual finding in this otherwise classic picture was that of the orbital abscess, the disease that is most commonly mistaken for thrombosis of the cavernous sinus.

On Jan. 1, 1943, approximately two months after the original trauma to the nasal furuncle, the patient left the hospital clinically well and remained perfectly well for two weeks, until he contracted a head cold following a hunting trip.

On his readmission, February 2, there was roentgen evidence of pansinusitis on the left and osteomyelitis of the left side of the frontal bone as well as definite neurologic findings, while during the previous admission there was no clinical or roentgen evidence of sinusitis.

According to the pathologist, the immediate cause of death was the extensive acute myocarditis, rather than the chronic basilar meningitis, which was minimal.

Therefore, one must wonder whether the patient would have survived the thrombosis of the cavernous sinus if he had not later contracted severe frontal sinusitis, followed by osteomyelitis of the left side of the frontal bone. An unanswered question is whether the osteomyelitis arose from the infection in the frontal sinus or was a metastatic lesion from his previous septicemia.

Another interesting problem is presented by the orbital abscess, as he did not have sinusitis at the time that he had the abscess. Was this another metastatic lesion from his septicemia, or did a thrombus in an orbital vein liquefy and rupture into the orbit?

In the face of a desperate situation this patient was given large doses of sulfonamide compounds over a long period, with apparently no ill effect. This absence of ill effect was, I believe, at least partially due to his high intake of fluids, which averaged 5,000 cc. daily, and to the numerous small blood transfusions that he received.

University of Kansas Hospital.

# Progress in Otolaryngology

## Summaries of the Bibliographic Material Available in the Field of Otolaryngology for 1943

## THE PARANASAL SINUSES

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The literature for 1943 is characterized by the large number of articles dealing with effects of drugs on the nasal mucosa and the value of various sulfonamide compounds used alone or in combination with vasoconstrictors in the treatment of sinus disease and general infections of the upper respiratory tract. It is difficult to evaluate this work at the present time because of the variable factors involved in each instance and the lack of an acceptable common denominator. Interest in these compounds is at fever heat, and there is no doubt that they are being widely used, perhaps indiscriminately and possibly with some danger to certain patients. More controlled experiments may be necessary before an accurate appraisal can be made. These, no doubt, will be forthcoming as time goes by.

### CONTRIBUTIONS TO THE ANATOMY, THE PHYSIOLOGY, THE PATHOLOGY AND THE BACTERIOLOGY OF THE PARANASAL SINUSES

Brandt and Roper-Hall [1] made serial sections and reconstructed the paranasal organ of an 8 cm. fetus (14 weeks), showing the common origin of the frontal sinus, the ethmoid cells and the antrum from one recess. The frontal sinus appears to be merely the most anterior and largest of the developing cells of the ethmoid labyrinth. The common opening of these embryonic cavities is slitlike, running the whole length of the upper border and parallel to it.

The model also shows that the axis joining the embryonic frontal recess and the antrum is at an angle of 65 degrees. This seems to explain the so-called frontomaxillary canal described by Filor. Another interesting observation in this model is the close relationship between the developing tooth germ and the antrum. In some places strands of mesenchyma can be seen connecting the two. Furthermore, the specimen reveals the presence of a sphenoid sinus at this early date.

1. Brandt, W., and Roper-Hall, H. T.: Clinical Aspects of the Embryonic Relations of Paranasal Sinuses to the Adjacent Structures, M. Press & Circ. **105**:190 (March 24) 1943.

Güttner [2] sought to determine the influence of early synostosis of the cranial bones on the development of the accessory nasal sinuses. Careful measurements were made in a series of skulls and in 2 with asymmetric halves due to porencephaly. His investigations showed that early closure of the cranial sutures interferes with the full development of the sinuses, especially the frontal ones, through pressure of the growing brain. He concludes that the development and the size of the sinuses are inherent in the bone itself, and that Wittmaack's theory is therefore not tenable.

De Lejarza [3] reports 2 cases in which congenital absence of the frontal sinus (bilateral in 1) was diagnosed by roentgenology, the patients having applied for relief from severe frontal pain. Ewing's sign was absent, but the pain was increased on bending the head forward. In 1 instance a syphilitic history was obtained; the patient, however, was supposed to have been cured. Both patients were relieved by injections of vitamin B.

Netto's [4] investigations of the shape and the size of the maxillary sinuses resulted in no new knowledge. He agrees that the sinus can reach its normal development only through normal dentition, its eventual shape being that of a triangular pyramid.

Gruner [5] presents an interesting study of constitution in relation to sinusitis. There are three theories on this subject, namely, Kretschmer's "body type," Albrecht's "mucous membrane constitution" and Lampert's "reaction type." The author favors the last named, which divides the subjects into two groups, the microkinetic and the macrokinetic. By the former term is

2. Güttner, H. G.: Formbeeinflussung der Nebenhöhlen des Schädels durch vorzeitige Nahtsynostosen, Beitr. z. path. Anat. u. z. allg. Path. **107**:271, 1942.

3. de Lejarza, C.: Sobre dos casos de ausencia congénita del seno frontal, Rev. méd. cubana **54**:322 (April) 1943.

4. Netto, B.: Da forma do seio maxilar-investigacoes pessoais, Rev. med.-cir. do Brasil **50**:85 (July-Aug.) 1942.

5. Gruner, R.: Reaktionstyp und chronische Nebenhöhlenentzündung, Arch. f. Ohren-, Nasen- u. Kehlkopfh. **151**:197, 1942.

meant a status in which the patient's reaction to various stimuli is weak; this status is represented by the hypotonic-asthenic symptom complex, namely, low blood pressure, weak muscle tonus, low gastric acidity, general atony and need of much sleep. The macrokinetic type is characterized by sharp reaction to stimuli with overactivity of the vasomotor system and a tendency toward allergy. Between the two extremes lie combined forms with predominance of one or the other.

The author tested a number of persons in a room in which the temperature was kept at 27 C. and the humidity at 60 per cent. After preliminary recording of the pulse and the temperature, the subject's feet were immersed in a footbath at 44 to 45 C. and the pulse and the temperature recorded at five minute intervals up to twenty-five minutes. The resulting graphs indicated the type of reaction. Patients in the microkinetic group showed a slow rise in temperature after five minutes, reaching a maximum of 0.2 C., and an increase of pulse rate between 5 and 10; those in the macrokinetic group showed a rise of temperature of 0.9 C. within fifteen minutes and an increase of pulse rate, after an initial drop of 10 to 15, to 25 above normal. Furthermore, sweating broke out much earlier in the macrokinetic than in the microkinetic group.

In addition, the author recorded the latent period after dermography on the arm and on the interscapular region. The reaction was more prompt in the macrokinetic type. An analysis of 80 subjects showed that in a group of 6 definitely microkinetic to 4 definitely macrokinetic the majority varied in the degree of their responses so that the individual subject could be classed as tending predominantly toward one or the other. Only 18 of the series could be considered "normal." These findings when applied to a study of patients with sinus disease revealed the following facts: The microkinetic type showed a tendency toward purulent sinusitis without much hyperplasia and rarely with polyp formation. The course of the sinusitis was uniform, with tendency to heal slowly, more frequent necessity for surgical intervention and a tendency toward recurrence. The macrokinetic type was characterized by edematous, hyperplastic, polypoid mucosa and the sinusitis by frequent intercurrent acute attacks, good reaction to therapy and frequent association with allergy. The author points out that an appreciation of these constitutional factors should aid materially in directing the therapy since the microkinetic type requires methods that will stimulate the humoral processes, while the macrokinetic type needs therapy that will reduce the vasoreactions and control the edema. In other words, the first type is the one that will be influenced mostly through constitutional therapy, whereas the second requires both local and constitutional treatment.

Dean and Diehl [6] report 2 cases in which chronic suppuration of the maxillary sinus was treated by the Caldwell-Luc operation and small nodules of bone were found within the hyperplastic mucosa. These were diagnosed as osteophytes, described originally by Zuckerkandl. According to the latter, they are derived from the fibroperiosteal lining of the sinus, which merges into the true mucosa. Ossification may take place in this sheath as a result of chronic inflammation and may result either in thin bony plates or in small isolated nodules, which later become detached and isolated within the mucosa.

Pickworth [7] again brings up for discussion the pleomorphism of pathogenic bacteria immured within the mucosa of the nasal sinuses. He shows a number of slides illustrating streptococci in various stages of degeneration and atypical appearance. He believes that after the original infection reaches a state of balance in which the bacteria, instead of being completely digested, are inhibited and attenuated, while the tissues at the same time fail to recover their preinfection state, a long period of freedom from symptoms may ensue after which the patient may experience an acute recurrence of the original symptoms. More important in the author's opinion is the effect of the slow absorption of toxic products from the focus, typical examples of which were presented in previous communications by the same author.

Under the direction of the Influenza Commission of the United States Army, observation posts were set up in various parts of the country for early detection of influenza in Army personnel. Salk, Menke and Francis [8] report the finding of influenza virus type A in the washings from the throats of several patients at a station hospital. The findings were established through animal inoculation. The value of this procedure lies in the early detection of the virus before the disease has spread in epidemic form, thus giving warning so that proper isolation measures may be taken.

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6. Dean, L. W., Jr., and Diehl, W. H.: Osteophytes of the Maxillary Sinus, Laryngoscope **53**:112 (Feb.) 1943.

7. Pickworth, F. A.: The Histobacteriology of Chronic Nasal Sinusitis, J. Laryng. & Otol. **58**:188 (May) 1943.

8. Salk, J. E.; Menke, W. J., and Francis, T., Jr.: Identification of Influenza Virus Type A in Current Outbreak of Respiratory Disease, J. A. M. A. **124**:93 (Jan. 8) 1944.

DIAGNOSIS

Moffett [9] states that the difficulty of obtaining uncontaminated specimens from the antrum for bacteriologic study is probably due to contamination from the vestibule or the nasal mucosa and to destruction of the organisms by the methods employed in extracting the specimens. He suggests the following procedure: preliminary cocainization; cleansing of the vestibule with "spirit," and drying of the excess with sterile cotton. The antrum is punctured with a Lichtwitz trocar and cannula, care being taken to avoid unnecessary contact with the nasal mucous membrane. Five cubic centimeters of sterile broth is instilled through the trocar, the patient's head being held forward and to the side. The amount of fluid instilled may be increased to 10 cc. if at first the aspiration fails to recover any. The aspirated fluid in the syringe is then transferred to a sterile tube for culture.

Hewson [10] suggests that percussion may yield valuable information as to the status of the maxillary sinuses if properly carried out in a quiet place. He recommends pressing the middle finger of the left hand into the soft tissues of the cheek over the canine fossa away from the alveolar process and using the middle finger of the right hand as the pleximeter. The patient's mouth should be closed, and the stroke should be firm, slow and steady. A normally pneumatized antrum containing air should yield a lower note than one containing fluid or tumor masses. The author has noted that this procedure often yields positive information when other diagnostic methods, such as transillumination, may be misleading.

Thiessing [11] calls attention to the possible ill effects of the contrast medium instilled into the antrum in certain cases. He cites a case in which thorium dioxide was found in the antrum as a foreign body two years after it had been injected. He feels, therefore, that the use of this medium should be restricted to cases in which the conventional roentgen studies are inadequate for the diagnosis or in which the procedure is likely to be followed by surgical treatment. (Comment: It is generally understood that a sinus which fills completely is normal, and if the injected fluid is of the right consistency, the normal ciliary action will expel it. On the other hand, if the filling is incomplete, this denotes pathologic alteration that requires surgical intervention, which would incidentally remove the foreign material. Furthermore, a routine check within a few days after the injection would disclose retained fluid, which is usually accepted as evidence of impaired ciliary function. S. S.)

Bayer and Werner,[12] who have contributed a number of articles on the critical analysis of planigrams, point out in the current article how one may err in the interpretation of coronal planigrams of the antrum. They show how the air contained within the antrum may obliterate the bony shadow of the orbital wall even though the cavity itself may not be in the plane at which the picture was taken. This effect might be mistaken for an erosion of the bone unless checked by other projections.

The same authors [13] find that the conventional projections of roentgenographed sinuses fail to reveal the extent and the location of the ethmoid cells and that defects following surgical treatment often fail to show clearly in such projections. They proved this in a series of roentgenograms taken from cadavers operated on, in which the exact extent of each surgical defect was known. They proved, further, that the only way in which these defects could be delineated was by planigraphy with pictures taken in series, both sagittal and frontal. They also showed that even "complete" exenteration of ethmoid cells by an external approach failed to remove aberrant ethmoid cells located in the roof of the antrum.

They therefore feel that one cannot always rely on the external approach as a certain method for clearing all the ethmoid cells. The illustrations accompanying the article are illuminating.

Bayer [14] demonstrates the course of the nasofrontal duct by means of planigraphy and illustrates the practical value of the planigram in arriving at the diagnosis of a small osteoma blocking the duct in 1 case.

Schuller [15] points out the fact that since individual variations in the size and the shape of the frontal sinuses are dependent on constitutional, hormonal and racial factors, adequate roentgenograms may be useful in the identification of the skull in the medicolegal cases as well as in the

9. Moffett, A. J.: A Technique for Obtaining Bacteriological Specimens from the Antrum, J. Laryng. & Otol. **57**:537 (Dec.) 1942.

10. Hewson, W.: Percussion Note of the Maxillary Sinus, Arch. Otolaryng. **38**:350 (Oct.) 1943.

11. Thiessing, G.: Ein Beitrag zur Frage der Schädigungen durch Kontrastfüllung der Kieferhöhle, Arch. f. Ohrenh-, Nasen- u. Kehlkopfh. **151**:356, 1942.

12. Bayer, H., and Werner: Schichtuntersuchung der Kieferhöhle und ihre Fehlerquellen, Fortschr. a. d. Geb. d. Röntgenstrahlen **66**:132 (Sept.) 1942.

13. Bayer, H., and Werner: Vergleichende Untersuchungen über das Siebbein und über Siebbeindefekte im Röntgenbild und Röntgenschichtbild, Fortschr. a. d. Geb. d. Röntgenstrahlen **65**:22 (Jan.) 1942.

14. Bayer, H. G. A.: Die Darstellung des Stirnhöhlenausführungsganges im Röntgenschichtbild, Ztschr. f. Hals-, Nasen- u. Ohrenh. **48**:333, 1942.

15. Schuller, A.: A Note on the Identification of Skulls by X-Ray Pictures of the Frontal Sinuses, M. J. Australia **1**:554 (June 19) 1943.

case of a war casualty. Comparison with previous roentgenograms of the same person should leave no doubt as to identity.

This was proved by Culbert and Law [16] in a case of record. The author states that congenital absence of the frontal sinuses is seen in about 5 per cent of all cases and unilateral absence in 1 per cent. Persistence of the frontal suture is often combined with absence of the sinus. Many other anomalies are mentioned and discussed. A diagram is presented showing a method of measuring the frontal sinuses in the standard forehead-nose position for purposes of identification. It includes measurement of the vertical and the horizontal limit and identification of the crista galli, the falx attachment, the jugum sphenoidale, the bulla ethmoidalis and other landmarks.

Mathé [17] finds lactobaryt [17a] a useful contrast medium for revealing the status of the antral lining. He shows several illustrations which demonstrate the value of this means of diagnosis as against the conventional roentgenogram.

### SINUSITIS IN CHILDREN

In a symposium the subject of sinusitis in children is covered broadly by Machado Ortega, Fuentes Cruz and Codinach.[18] Most of the material closely follows that which may be found in the medical press of the United States and the bibliography is predominantly North American. One might criticize the didactic manner in which sinus involvements are catalogued, knowing as one does that in children, as a rule, the infection is seldom isolated in one cavity. However, since due emphasis is placed on the concurrence of sinusitis with infections of the lower respiratory tract, as well as on the influence of allergic factors, one must credit the authors with a full appreciation of the complex problem. The only item that seems to have been overlooked is the influence of improper diets in the causation and pathogenesis. The therapeutic measures discussed include everything from local medication to radical surgical operation. It is good to note that the author of the paper on treatment points out the possible deleterious effect of indiscriminate and prolonged nasal medication.

During the period of six years from 1935 to 1941 there were 58 children in one institution who had to be treated surgically. Among these were several with paradental cyst, a few with osteomyelitis of the superior maxilla, a patient with thrombosis of a cavernous sinus who recovered (details not given), a patient with lymphosarcoma, a patient with lymphoma and a patient with fatal septicemia and hemorrhages following an operation for pansinusitis.

Fairbanks Barbosa [19] believes that infection of the sinuses in children is frequently overlooked because of the small size of these cavities and because symptoms referable to other organs overshadow the local signs. He cites allergy and hypertrophy of the tonsils and adenoids as potent predisposing factors, with severe cold, influenza or exanthems as exciting factors. The usual symptoms are listed, and the diagnosis is suggested on the basis of local findings and roentgen evidence.

The author recommends various therapeutic measures, including use of a diet rich in vitamin A, short wave and vaccines and local application of an isotonic solution of ephedrine and mild protein silver by the Proetz, Parkinson or de Lima technic. Few patients require surgical treatment. It is interesting to note that the author finds sinus disease more common in white children than in children of other races.

Tremble [20] finds the most common symptoms of sinusitis in children as reported by the parent to be nasal obstruction, cough and repeated colds. The diagnosis is based on presence of mucopus in the nasal chambers, engorgement of the middle turbinate and postnasal discharge; frequently he also finds inflamed pharyngeal bands and enlarged cervical glands. He recognizes the frequent presence of allergy in these patients and cites the usual observations and the methods of diagnosis. He devotes considerable space to a discussion of the influence of local medication on the nasal mucosa, citing much of the recent literature on the $p_H$ of various solutions. He speaks highly of a proprietary medicament manufactured in Montreal which consists of sulfathiazole 10 per cent, ephedrine sulfate 1 per cent and allantoin 0.5 per cent in an isotonic suspension the $p_H$ of which is 5.8. Allantoin has been found to be synergistic with the sulfonamide drugs. It

16. Culbert, W. L., and Law, F. M.: Identification by Comparison of Roentgenograms of Nasal Accessory Sinuses and Mastoid Processes, J. A. M. A. **88**:1634 (May 21) 1927.

17. Mathé, K.: Ueber den Wandbegleitschatten bei Röntgenaufnahmen der Kieferhöhlen, Ztschr. f. Hals-, Nasen- u. Ohrenh. **48**:211, 1941.

17a. This is a German proprietary product the composition of which is not known.

18. Machado Ortega, R.: Etiologia y patogenie, Arch. de med. inf. **12**:133 (July-Sept.) 1943. Fuentes Cruz, S.: De las sinusitis en la infancia; sintomatologia de las mismas, ibid. **12**:141 (July-Sept.) 1943. Codinach, A.: Tratamiento de las sinusitis en la infancia, ibid. **12**:149 (July-Sept.) 1943.

19. Fairbanks Barbosa, J.: Sinusites nas crianças, Pediat. prát., São Paulo **14**:51 (Jan.-April) 1943.

20. Tremble, G. E.: The Conservative Treatment of Sinusitis in Children, Canad. M. A. J. **49**:496 (Dec.) 1943.

stimulates cell proliferation and has a digestive-like effect on pus or necrotic tissue.

Silva Maricano [21] discusses infections of the maxillary sinus in infancy, referring mainly to osteomyelitis, a condition that was thoroughly described by Asherson in 1939 and abstracted in this review.[22] He advocates radical surgical treatment by the Caldwell-Luc approach.

### COMPLICATIONS OF SINUSITIS

*Oculo-Orbital Involvements.*—Goodyear [23] briefly mentions a few ocular diseases which may be due to sinus infection and indicates the measures that should be adopted. In cases of corneal ulcer he advises roentgen study of the antrum with use of a contrast medium and intranasal antrostomy if the roentgenograms show any thickening of the lining mucosa. As to optic neuritis of undetermined origin, he has seen spectacular results from the mere injection of iodized oil into the sphenoid sinus, so that operation was often avoided.

He claims that infants are often treated for dacryocystitis when the condition is really due to infection of the ethmoid cells. Simple exposure with an incision made through the periosteum usually suffices. The ethmoid cells are not entered unless the infection fails to subside promptly.

For mucoceles of the ethmoid labyrinth the author has found the intranasal approach adequate. The middle turbinate is split and the labyrinth opened widely to permit free drainage from the excavated cavity without necessarily disturbing its lining membrane.

Acute frontal sinusitis, especially that following swimming, is treated by early trephining through the floor of the frontal sinus. If the case is less fulminating and the patient has gone a week or more without relief, the author advises biting into the anterior ethmoid cells beneath the infracted middle turbinate and passing a finder into the frontal sinus, which is enlarged with a Pratt ring curet. A case in point is cited.

Ford [24] reports several cases of choroiditis and iridocyclitis of years' standing in which brilliant results followed simple intranasal drainage of previously unrecognized sinusitis. He states that in the 3 cases cited there was only one recurrence, which yielded promptly to the same therapy. The article would be much more valuable if he included more detail as to the particular sinuses involved and the character of the infection.

In another communication the same author [25] reports the case of a child of 7 who, seven months after an attack of scarlet fever, was taken very ill and operated on for mastoiditis without effect. External ocular palsy and bilateral optic atrophy developed. She was reported as being very nervous. Her tonsils and adenoids were removed and still there was no improvement. Boils appeared on the legs, and her pillow was frequently found stained in the morning. Diagnostic irrigation of the antrums returned only mucus, which on culture revealed a heavy growth of streptococci. The irrigations relieved the child's nervousness, the boils and the nocturnal nasal discharge but failed to clear up the optic neuritis. The author believes that the "silent" infection was responsible for the ocular complication and that if it had been discovered earlier the result might have been more favorable.

Blonder [26] reports a case of orbital cellulitis apparently due to maxillary sinusitis in a boy of 14. A Caldwell-Luc operation was performed, and although no dehiscence or erosion of the orbital floor was discovered, it was noted that the roof of the sinus was covered with a considerable amount of granulation tissue.

Davis' [27] patient was a soldier who, though giving a history of having suffered from intermittent frontal headaches for several years, was nevertheless accepted into the army, apparently during a symptomless interval. A few months later he contracted an acute infection of the upper respiratory tract which developed into an orbital abscess, which was incised and drained. The discharge persisted, and roentgenograms revealed cloudiness throughout all the sinuses of that side. After intensive treatment wtih sulfonamide compounds a Killian operation was performed, which revealed extensive disease in the frontal sinuses and ethmoid cells with some involvement of the bone. Subsequently a Caldwell-Luc operatioin was done, and the patient recovered.

In a patient of Woodson's [28] retrobulbar pain and impairment of vision of several years' dura-

21. Silva Maricano, J. R.: Antritis maxilar infantil, Pediat. Américas **1**:107 (Feb.) 1943.

22. Asherson, N., cited by Salinger, S.: The Paranasal Sinuses, Arch. Otolaryng. **32**:341 (Aug.) 1940.

23. Goodyear, H. M.: Diagnosis and Treatment of Nasal Sinus Disease in Relation to the Eye, West Virginia M. J. **39**:270 (Aug.) 1943.

24. Ford, R.: Iridocyclitis and Choroiditis Due to "Silent" Sinusitis, Brit. J. Ophth. **27**:469 (Oct.) 1943.

25. Ford, R.: Optic Atrophy Due to Paranasal Sinusitis in Scarlet Fever, Clin. J. **72**:185 (Sept.-Oct.) 1943.

26. Blonder, E. J.: Orbital Cellulitis Complicating a Maxillary Sinusitis, Ann. Otol., Rhin. & Laryng. **52**: 524 (June) 1943.

27. Davis, J. S.: Osteomyelitis with Fistula, Orbital Cellulitis and Abscess, and Diplopia Complicating Pansinusitis, Ann. Otol., Rhin. & Laryng. **52**:906 (Dec.) 1943.

*(Footnotes continued on next page)*

tion were found to be due to an infection of the sphenoid sinus, which promptly cleared up after the sinus was opened and drained. There is no mention of roentgen studies in this case, the diagnosis having been made on the basis of pus in the middle meatus and cloudiness on transillumination. In the second case reported an abscess of the nose, probably due to self trauma of a pimple, led to rapid involvement of the orbit with a subsequent fatal thrombosis of the cavernous sinus. Here too there is no mention of roentgen studies but a notation of pus in both sides of the nose. The author assumes that the ethmoid cells and the sphenoid sinus were involved. The third patient, a boy of 8, had a history of gonococcic conjunctivitis in early childhood with possible reinfection six years later, although cultures were negative. A large chalazion was present which the author believes may have been the origin of the infection which later involved both orbits and gave rise to symptoms of an involvement of the cavernous sinuses. Roentgenograms revealed clouding of all of the sinuses on one side, and there was marked edema of all the eyelids spreading to the forehead, the face and the neck. Pus was evacuated through a puncture of the forehead and also from the bulging septum. Marked toxemia was present. The patient recovered after treatment with massive doses of sulfadiazine. (Comment: It is questionable whether there was thrombosis of the cavernous sinuses since there is no mention of changes in the fundi, ophthalmoplegia or a positive blood culture and since the spinal fluid was normal. S. S.)

El Bakry [29] cites 2 cases in which keratitis in a young person was found to have been caused by chronic ethmoiditis. In both instances conservative treatment of the sinus disease resulted in disappearance of the ocular symptoms. In 1 case the patient had acute coryza in the beginning, followed by keratoconjunctivitis, local swelling and external perforation with discharge of mucopurulent secretion. The fistula was found to lead directly into the ethmoid labyrinth through a perforation of the lamina papyracea. Treatment consisted of short wave diathermy and the use of sulfonamide drugs.

The author believes that the keratoconjunctivitis is caused by infection transmitted via lymph and blood streams from a focus of osteitis within the ethmoid labyrinth.

In addition to the 2 cases just cited the author reports 20 additional cases of keratitis in which pathologic changes were present in the sinuses, chiefly in the ethmoid cells, which yielded to nasal therapy in a few days. There were only 2 cases in which a recurrence developed.

Halbron [30] discussed the relationship of sinus disease to retrobulbar neuritis, with many references to the literature. While in certain cases the pathologic condition of the sinuses can be readily diagnosed, these cases are in the minority, and controversy has arisen only with reference to the group in which the symptoms and the findings are negligible. He objects to the term "sinusitis without sinusitis" employed by some authors to designate the condition in those cases in which the operative findings were negative but in which the neuritis promptly subsided. He claims that in these cases there must be some local pathologic process, either edema of the mucosa or osteoperiostitis, capable of causing compression of the optic nerve.

Scrupulous examination of the nasal passages, the mucosa, the turbinates and the ethmosphenoid area, together with study of accurate roentgenograms, should in the vast majority of cases disclose sufficient deviation from the normal to justify a diagnosis of sinusitis. Several cases are cited in which a history of frontal headache was elicited and in which histologic examination of mucosa excised from the suspected sinus revealed cellular infiltration in the hyaline stroma.

The author feels that in no case should examination of the sinuses be neglected. If signs of infection are present, he advises immediate operation. On the other hand, in the absence of definite sinusitis, if other therapy fails and the condition becomes progressively worse by the end of a week, one is justified in opening the sphenoid sinus on the basis of the favorable experiences frequently cited in the literature.

Snow [31] reports 5 cases of orbital abscess complicating sinus infection. He advises early drainage via the external ethmofrontal approach and the avoidance of any extensive surgical operation.

*Intracranial Involvements.*—The recognition of subdural abscess has always been a difficult problem because of the accompanying symptoms arising out of the preceding and accompanying sinusitis as well as the possible presence of other

28. Woodson, B.: Some Sphenoid Symptoms Associated with Abnormal Vision: Case Report of Thrombosis of the Cavernous Sinus with Recovery, M. Rec. & Ann. **37**:593 (July) 1943.

29. El Bakry, M. M.: New Views About Trachomakeratitis and Its Treatment, Bull. Ophth. Soc. Egypt **33**:53, 1940.

30. Halbron, P.: Les nevrites optiques retrobulbaires et leur origine sinusienne, Arq. brasil. de oftal. **5**:207 (Oct.) 1942.

31. Snow, W. J.: Orbital Complications in Suppurative Sinus Disease, Texas State J. Med. **38**:557 (Jan.) 1943.

complications. Ray and Parsons [32] present the histories of 3 cases, all of which came to autopsy. They feel that the most important factors in the pathogenesis are osteitis of the posterior wall of the frontal sinus and thrombophlebitis of small veins in the mucosa of the sinus. The latter furnish the pathways for infection to the dura long before the intervening bone has succumbed. While in some instances the infection is carried directly to the superior saggital sinus and cerebral veins, most of the data at hand seem to indicate that the subdural space is infected by direct penetration of the dura itself. The importance of careful exposure of the dura with elimination of all pockets of extradural infection is emphasized as a possible prophylactic measure against penetration of the dura. As for symptoms, while early characteristic symptoms may be lacking, it has been observed that in all cases in which the diagnosis is later confirmed, headache, nasal discharge, fever and malaise are present for varying periods until the sudden dramatic appearance of convulsions, jacksonian seizures or hemiplegia. The headache is usually homolateral, and the motor symptoms are contralateral. The authors point out that the answer to the question whether the posterior wall of the sinus should be removed at the primary operation depends not only on the status of the bone at the time but also on the presence or the absence of symptoms suggesting intracranial invasion. The persistence of headache after the sinus has been opened suggests dural invasion and indicates the necessity for further exploration. When a subdural abscess is diagnosed, it should be exposed through a trephine opening in the frontotemporal area, and if the abscess is located, sufficient exposure should be made through additional trephine openings to permit adequate drainage. The occipital approach is also recommended as being favorable for drainage by gravity.

Piquet [33] reviews the literature on the incidence of meningitis as a postoperative complication following various nasal operations and refers to Loeb's comprehensive survey in 1923 and 1924. He cites a half-dozen cases. Two of the patients survived under treatment with sulfonamide compounds; the others died. The operations which preceded meningitis included removal of a small intranasal growth with a snare, resection of a septum, intranasal ethmoidectomy and external operation for a carcinoma of the ethmoid labyrinth involving the orbit. Discussing the question whether such serious complications can be prevented, he claims that most rhinologists believe that if surgical treatment is to be thorough and complete, one must run the risk. One cannot exclude the possibility of a postoperative intracranial complication except through inadequate or timid surgical treatment. The causes of such complications are fragility of the roof of the ethmoid labyrinth due to age or atrophic changes, dehiscence or other abnormalities. He says nothing about the danger of operating in the presence of acute infection or of incompetent or ill advised surgical intervention.

He advises prompt and adequate administration of sulfonamide compounds in any case in which there is a suspicion of possible damage to the osseous boundaries and warns against being lulled into a false sense of security by a symptomless interval, which occasionally intervenes.

Meningitis following infection of an antrum is rare. Spencer-Harrison's [34] patient was a man of 30 who had suffered two severe attacks of sinusitis in 1941 and 1942, accompanied by swelling of the cheek. Three months after the last attack he entered the hospital with the condition in a quiescent stage. Roentgenograms showed marked cloudiness of the antrum, and irrigation produced considerable pus. A Caldwell-Luc operation revealed extensive disease of the mucosa, which was thoroughly cleaned out. Instead of improving, the condition became worse. The cheek became swollen, and signs of intracranial involvement ensued. The fluid was turbid and contained 640 cells but revealed no organisms on culture. Improvement followed sulfapyridine therapy, but a short time later the patient showed symptoms of a cerebellar abscess. This was opened and drained, despite which the patient succumbed. Autopsy showed that the infection reached the meninges from the sinus by way of the infraorbital canal.

*Arthritis.*—From an analysis of 166 cases, Klunker [35a] is convinced that the maxillary sinus may harbor a focus of infection responsible for symptoms in remote areas. The responses to his questionnaire showed that 108 of the 166 patients had a definite history of either articular rheumatism alone or of this in association with

32. Ray, B. S., and Parsons, H.: Subdural Abscess Complicating Frontal Sinusitis, Arch. Otolaryng. **37**: 536 (April) 1943.

33. Piquet, J.: Die Sulfamidbehandlung in der Prophylaxe der postoperativen Meningitis, Monatschr. f. Ohrenh. **76**:68 (Feb.) 1942.

34. Spencer-Harrison, M. E.: Infection of the Meninges in Maxillary Sinusitis, J. Laryng. & Otol. **58**:196 (May) 1943.

35. (*a*) Klunker, H.: Kommt die chronisch entzündete Kieferhöhle als Fokus in Betracht? Ztschr. f. Hals-, Nasen- u. Ohrenh. **42**:307, 1942. (*b*) Vogel, K.: Die Herdinfektion im gebiet des Hals-, Nasen, und Ohrenarztes, in Schoen, R.: Der Rheumatismus, Leipzig, Theodor Steinkopff, 1940, vol. 17.

symptoms referable to the heart, the digestive tract and the skin or such vague symptoms as chronic fatigue and lassitude. These symptoms were present for periods of six months to twenty-five years. All of the patients had undergone a Caldwell-Luc operation revealing chronic sinus infection, and the results so far as their other complaints were concerned showed either cure or definite improvement in three fourths of the entire group.

Klunker's results are in marked contrast to those published by Vogel [35b] in 1940.

Ford [36] cites a case of rheumatoid arthritis of five years' duration in a young woman which was associated with chronic sinusitis of the "silent type." There were deformities of the legs, arms, hands, back and neck, iritis and marked emaciation. Intranasal medication brought on a flow of thick mucus, and continued therapy led to remarkable relief within a few weeks. No details are presented as to which sinuses were involved or whether roentgenograms were taken, but the case is interesting nevertheless because of the sequence of events. A much more detailed account including bacteriologic studies would have added much to the value of the report.

*Pulmonary Complications.*—McLaurin [37] discusses the relationship between sinusitis and bronchiectasis. He finds that unilateral bronchiectasis, as a rule, has its origin in childhood, being due to atelectasis following plugging of smaller bronchi by aspirated thick secretion. He is convinced that aspiration of discharges from the sinuses is an important means of transmission of infection to the lower respiratory tract and cites the experiments by himself and others in which iodized poppyseed oil 40 per cent instilled into the sinuses was later detected roentgenologically in the lower respiratory tract. In addition to the transmission by aspiration or by droplets the author mentions the lymphohematogenous and the hematogenous routes and the route by direct continuity of tissue. He states that in 85 to 100 per cent of all cases of chronic bronchitis, bilateral bronchiectasis and peribronchitis the condition is due to infection of the upper respiratory tract.

Goodale [38] studied a series of 75 cases of bronchiectasis from the point of view of the evaluation of surgical therapy. He presents tables showing the results obtained from operation on the sinuses alone and from this procedure in combination with lobectomy and shows that the best results were obtained in those cases in which adequate surgical treatment of the sinuses was combined with lobectomy. Complete cure so far as absence of symptoms referable to the sinuses and the chest was concerned was obtained in only a small proportion of cases. However, a large percentage of the patients were so greatly benefited that the procedures were felt to be fully justified.

Simonton,[39] reporting on several cases of bronchiectasis associated with sinusitis in which lobectomy had been performed, stated that the infection of the sinuses yielded promptly to adequate surgical therapy after the preliminary focus had been removed. He feels that the unsuccessful therapy of sinusitis associated with bronchiectasis is due to reinfection by secretions coughed up from the lungs. Therefore, the author contends that when the two conditions are present, if the conditions are suitable for lobectomy treatment of the infection of the sinuses had better be deferred until after the pulmonary condition has been eliminated.

Kennedy [40] presents an analysis of 100 cases in which transient pulmonary shadows were detected by mass roentgenography. He describes three distinct groups, namely, bronchopneumonic, pneumonic and basal striations. The last-named striations are due to small lesions which regress spontaneously within two to three weeks and give rise to few symptoms aside from cough and a small amount of mucous secretion. It was noted that these were usually associated with an infection of the upper respiratory tract, and the author believes that the infection is a descending one causing localized inflammation of the bronchi up to the third bifurcation.

Lederer [41] reviews the recent literature on the interrelationship of sinusitis and bronchiectasis, from which he concludes that an etiologic basis for the latter does exist in the former.

Riggs [42] cites the literature on sinusitis as an etiologic factor in bronchiectasis and other bron-

36. Ford, K.: A Case of Rheumatoid Arthritis and Infected Paranasal Sinuses, Practitioner **150**:178 (March) 1943.

37. McLaurin, J. G.: Interrelationship of Upper and Lower Respiratory Infections, Ann. Otol., Rhin. & Laryng. **52**:589 (Sept.) 1943.

38. Goodale, R. L.: Effect of Surgical Treatment of the Sinuses on Bronchiectasis, Arch. Otolaryng. **38**:148 (Aug.) 1943.

39. Simonton, K. M.: Observations on Paranasal Sinusitis Among Patients Subjected to Lobectomy for Bronchiectasis, Ann. Otol., Rhin. & Laryng. **52**:598 (Sept.) 1943.

40. Kennedy, J. A.: Pulmonary Complications of the Common Cold and Sinusitis, Lancet **1**:769 (June 19) 1943.

41. Lederer, F. L.: Nasal Sinusitis in Relation to Bronchiectasis: A Review, Dis. of Chest **9**:50 (Jan.-Feb.) 1943.

42. Riggs, R. N.: Sinusitis in Diseases of the Lower Respiratory Tract, New Orleans M. & S. J. **95**:475 (April) 1943.

chopulmonary involvements and calls attention to the necessity of investigating the sinuses of patients with these conditions for possible occult infection.

*Osteomyelitis.*—Brunner [43] distinguishes two types of chronic osteomyelitis, namely, primary and secondary. Under the former he includes cases in which there is no history of an acute phase. Among 7 cases in this group which he discusses in detail there were 5 in which the osteomyelitis was not associated with any infection of the sinuses but was due to such causes as erysipelas, scarlet fever, trauma and cancer. According to Brunner, this type of osteomyelitis is characterized by a protracted course with few alarming symptoms and a tendency toward localization, frequently with abscess and fistulization, and eventually toward sequestration. Pathologically he observes a marked tendency toward thickening of the frontal bone due to activity of osteoblasts, which may obscure the outlines of the sinus and cause some difficulty in the roentgen interpretation. Considering the therapy, the author advocates an obliterating operation if the frontal sinus is involved; otherwise he advises waiting until sequestration is completed before opening the sinus.

Under the secondary type of chronic osteomyelitis Brunner presents 4 cases in which there was a history of preceding acute sinusitis. These cases were characterized by an acute onset followed by a slowly developing, spreading osteomyelitis with symptoms of sepsis and frequently metastasis. In this type, as in the primary, osteogenesis predominates, with thickening of the bone and later sequestration. The author points out, however, that a difference between the two types may be apparent in the roentgenograms. The sclerosis of the primary type is found in the boundaries of the sinus, tending to spread slowly, whereas in the secondary type the boundaries of the sinus may regain their clarity and the sclerosis may appear in distant areas. Discussing the therapy, he appears to be somewhat uncertain as to what procedures to advise, because of the septicemia, the metastasis and the widespread foci in the skull. He seems inclined to rely on treatment with sulfonamide compounds, reserving surgical procedures for evacuation of abscess cavities or removal of sequestrums.

Simpson [44] reviews a series of 18 cases in which osteomyelitis of the skull resulted from sinus infection, 3 of them fatal, and discusses the various phases of the disease as it appeared to him. The 18 cases are abstracted in essence and numerous practical points deduced. The author feels that one should not be too arbitrary in dividing osteomyelitis into localizing and spreading types since he has seen the former develop rather suddenly into the latter. It is much safer to regard every patient as one with potential spreading osteomyelitis and apply the same thorough surgical procedure as if in fact the osteomyelitis were spreading, which means adequate removal of a sufficiently extensive area about the diseased focus. The accompanying photographs show that several different surgical approaches were employed, depending on the extent of the lesion.

Considering the prevention of osteomyelitis, the author is convinced that in cases of acute involvement of the frontal sinus much can be accomplished by external drainage. He likens these 7 cases in which the disease failed to yield promptly to conservative measures to a case of acute suppuration of the middle ear, in which, he says, "the surgeon does not wait until there is a subperiosteal abscess, etc., before suggesting drainage of the mastoid." The procedure he recommends is that of making a curved incision below the brow, elevating the periosteum, and opening the frontal sinus from below with an Alexander gouge and bone forceps. The anterior ethmoid cells are also opened, but no curetting is done, and care is taken to avoid trauma to the mucosa of the frontal sinus. Drainage is accomplished through a small rubber tube. In avoiding, also, any trauma to the anterior wall of the sinus, osteomyelitis may be prevented. The author has never seen this develop following the procedure which he recommends for acute sinusitis with a history of suppuration, increased density of the frontal sinuses, marked local tenderness, intranasal drainage or beginning edema.

The case presented by Gama and de Rezende Barbosa [45] was one in which a successful result was obtained through radical surgical intervention according to the procedure described by Furstenberg. The patient had chronic bilateral suppurative pansinusitis and had undergone several operations over a period of months before the symptoms of osteomyelitis appeared. This sort of case is typical of a group in which failure to evaluate properly the extent of the sinus disease and to eradicate the infection thoroughly results only in further extension of the disease.

43. Brunner, H.: Chronic Osteomyelitis of the Skull, Ann. Otol., Rhin. & Laryng. **52**:850 (Dec.) 1943.

44. Simpson, W. L.: Osteomyelitis of the Skull Resulting from Infection in the Sinuses, Arch. Otolaryng. **37**:463 (April) 1943.

45. Gama, C., and de Rezende Barbosa, J. E.: Osteomielite frontal: Operação de Furstenberg, Rev. brasil. de oto-rino-laring. **10**:573 (Sept.-Oct.) 1942.

It serves as an excellent example of failure to obtain results through inadequate surgical treatment.

Dingley's patient [46] presented symptoms of involvement of the frontal sinuses two days after having been in a public pool. Beginning with headache, fever, supraorbital edema and local tenderness there soon developed epileptiform attacks, well marked asphasia and unconsciousness. An opening was made in the frontal sinus, disclosing pus and a degenerated mucosa but an intact posterior wall. A subperiosteal abscess broke through the incision, which was then enlarged into a flap, base downward, so as to expose the frontal bone. Although this appeared normal, a trephine opening disclosed pus in the diploe. A large amount of bone was removed, and because the dura failed to pulsate, it was opened in the expectation of revealing a subdural abscess. Probing failed to reveal any intracranial abscess. The patient recovered. The author comments on the transmission of the infection via diploetic veins. He mentions having removed only one half of the frontal bone, contrary to Mosher's advice that both halves be taken away. By this he does not intend to convey the impression that Mosher is wrong but to indicate the localization of the disease in his case and possibly also the value of the sulfonamide compounds employed.

The case reported by Giordano and Spataro [47] was one of subacute localizing osteomyelitis of the frontal bone, symptoms having appeared forty days prior to the patient's admission to the hospital. The infection was well localized, destruction could be readily seen in the roentgenograms, and operation, revealing pus and a sequestrum, led to prompt recovery.

Jones [48] points out the danger of the rhinologist's relying too much on the sulfonamide drugs when dealing with spreading osteomyelitis of the frontal bone. The case he cites was a long drawn out affair with several remissions during which the patient seemed to be getting better only to relapse from extension of the disease. The patient was operated on several times and in the end, after his condition apparently improved, suddenly died. The postmortem examination revealed an abscess of the frontal lobe. The author feels that continued administration of sulfonamide compounds definitely masks the clinical symptoms, and in his opinion radical surgical intervention should not be delayed when the patient fails to progress to a definite recovery.

46. Dingley, A. R.: Acute Frontal Osteomyelitis with Subdural Abscess, J. Laryng. & Otol. **77**:450 (Oct.) 1942.

47. Giordano, F. P., and Spataro, A. I. L.: Osteomielitis del hueso frontal, Semana méd. **2**:1304 (Nov. 26) 1942.

48. Jones, A. C.: Incorrect Treatment of Osteomyelitis of the Frontal Bone, Arch. Otolaryng. **38**:547 (Dec.) 1943.

### MALIGNANT TUMORS

Schall [49] sounds a hopeful note in discussing cancer of the sinuses but points out the importance of viewing with suspicion any unilateral obstruction of the nose, particularly when associated with hemorrhage. He is a staunch advocate of early biopsy and exploratory operation in all cases arousing suspicion of cancer. He advocates adequate exposure of the affected area through a modified Moure incision made with the diathermy cutting current and extended well beyond the palpably involved area. Since this extension is often impossible, it is recommended that the operation be followed by intramural irradiation with radium, the orbit being protected with at least 1 mm. of lead. The author has found a potassium permanganate spray useful in counteracting postoperative odor.

A rather unusual case of undifferentiated carcinoma of the antrum in a man of 43 is reported by Harbert.[50] There was a history of several previous operations for removal of nasal polyps. When admitted to the hospital the patient had a definite swelling below the inner canthus with intranasal bulging in the region of the ethmoid cells and the inferior turbinate. The antrum was found to be filled with a large soft lobulated grayish red tumor extending into the ethmoid labyrinth with erosion into the orbit and into the tissues of the face. About this time there were clinical evidences of metastases in the spinal column, which, however, failed to show up in the roentgenograms. The patient's condition became progressively worse, with paralysis of the arm, the lower extremities and the bladder. Autopsy revealed metastatic foci in the clavicle, the second and third chondrosternal junctions and the first and tenth thoracic vertebrae. Failure of the roentgenograms to reveal the lesions in the vertebrae is ascribed to the preservation of the bony trabeculae of the cancellous spaces.

Ellis [51] reports a case of adenocarcinoma in a child of 12 which involved the ethmoid cells and crowded one side of the nose so as to cause an external deformity. Nasal hemorrhages were present for several weeks previously. The mass was removed by operation on the ethmoid

49. Schall, L. A.: Cancer of the Nose and Nasal Sinuses, Laryngoscope **53**:240 (April) 1943.

50. Harbert, F.: Unusual Neoplasm of the Antrum, U. S. Nav. M. Bull. **41**:1405 (Sept.) 1943.

51. Ellis, B. E.: An Unusual Nasal Tumor, Arch. Otolaryng. **38**:65 (July) 1943.

labyrinth through an external approach, the removal being preceded and followed by irradiation. The Caldwell-Luc operation was done subsequently to eradicate a possible extension. There was no recurrence up to two years.

Anderson [52] calls attention to the paucity of symptoms in his case. The patient, a woman of 59, complained of numbness over the right side of the face and along the gums of the lower jaw, accompanied by a burning sensation in the hard palate. Local examination showed practically nothing abnormal, but roentgenograms revealed a dense shadow involving the antrum and the ethmoid labyrinth. A radical antrostomy was done which disclosed a mass occupying two thirds of the antrum and invading the nasal and orbital walls. Biopsy revealed epidermoid carcinoma. The mass was removed via a Moure exposure and was found to extend deeply within the ethmoid labyrinth, involving the roof so that the dura was exposed. Intracavity irradiation followed the operation for a total of 1,200 milligram hours. The primary result was satisfactory.

Thompson's [53] case was that of a man (age not given) whose complaints were pain in the cheek of three months' duration, recent tenderness, and bleeding from the nose. There was a history of prolonged nasal discharge. The mass caused bulging externally as well as intranasally. Biopsy showed squamous cell carcinoma. At operation the neoplasm was found to have invaded the cheek, the orbital wall and the ethmoid cells. After electrocoagulation three capsules of radium (12.5 mg. each) were packed into the cavity and three needles of the same potency were inserted into the ethmoid labyrinth. Later the nasoantral wall was removed and external irradiation given totaling 1,704 r. The patient was free from evidence of recurrence up to six years.

Carcinoma of the sphenoid sinus, according to Hardie and Ahronheim,[54] may follow one or more of the following routes to adjacent structures: (1) orbital, the most common, (2) nasal, (3) cranial, (4) petrous and (5) occipital. The case they report was unusual in that the lesion followed the last-named (occipital) route, extending through the body of the sphenoid bone into the foramen magnum. It was a poorly differentiated type of squamous carcinoma, originating in the left sphenoid sinus of a woman of 30, the early symptoms of which were pain in the left ear and the mastoid process. The Caldwell-Luc operation, ethmoidectomy and mastoidectomy failed to reveal the true nature of the trouble. Subsequently the sphenoethmoid cavities on the left were opened by an external approach and a mass uncovered in the sphenoid sinus, which had already apparently eroded the posterior and lateral walls. Histologically it was medullary squamous carcinoma of grade 3. Autopsy revealed involvement of the base of the skull extending into the foramen magnum and of the apex of the petrous bone, the sella turcica and a portion of the atlas.

### NONMALIGNANT TUMORS

In the first of the 2 cases of osteoma reported by Jorge and Almada [55] it was necessary to resect the supraorbital vessels and nerve because of their intimate association with the tumor. The latter involved the frontoethmoid junction with invasion of the floor of the frontal sinus and the anterior ethmoid cells. However, they were able to remove the mass without breaking down the contour of the supraorbital ridge. In the second case the tumor invaded the orbit, causing a displacement of the bulb. In both cases there were few subjective symptoms, the patients seeking medical advice because of the appearance of an external deformity.

De Villiers [56] reports a case of eburnated osteoma of the frontal sinus in a man of 24, whose complaint was severe frontal pain. From the location of the tumor, which on removal measured 2.5 by 1.5 cm., the pain seemed evidently due to pressure on filaments of the supraorbital nerve.

The interesting feature of Johnston's [57] case was the unusual site of origin of the osteoma. It was attached to the roof and the anterior wall by a pedicle about 5 mm. in diameter. The mass itself measured 26 by 24 by 6 mm. and had a prolongation downward which fitted snugly into the funnel-like beginning of the frontal nasal duct. Roentgenograms taken six years prior to the operation and compared with those made at the time of operation showed a very slow rate of growth. The symptom which led to the diagonsis and subsequent removal of the tumor was dizziness, which disappeared within a few days after the operation.

52. Anderson, C. A.: Malignancy of the Antrum and Ethmoids, M. Times, New York **71**: 180 (June) 1943.

53. Thompson, H. E.: Carcinoma of the Antrum, J. Iowa M. Soc. **33**:550 (Dec.) 1943.

54. Hardie, G. C., and Ahronheim, J. H.: Primary Carcinoma of the left Sphenoid Cavity, Arch. Otolaryng. **38**:497 (Nov.) 1943.

55. Jorge, J. M., and Almada, S. E.: Osteomas fronto-etmoido-orbitarios, Bol. y trab., Acad. argent. de cir. **27**:331 (June 16) 1943.

56. de Villiers, R.: Extirpación de un osteoma del seno frontal, Vida nueva **51**:125 (April) 1943.

57. Johnston, W. H.: Osteoma of the Frontal Sinus, Arch. Otolaryng. **38**:318 (Oct.) 1943.

Weaver's [58] case was that of a man of 35 who complained of fronto-occipital headache for over a year. Roentgenograms revealed an antral cyst containing an unerupted third molar tooth. This was successfully removed by the Caldwell-Luc procedure.

McNally, Stuart and Childe [59] cite 5 cases of mucocele of the frontal sinus, in 2 of which the cavity was found to be empty at operation. They point out the importance of differentiating this entity from hydatid cyst, epidermoid and meningocele. These are all discussed in brief and essential details pointed out. The roentgen examination is stressed and well illustrated. The authors state that one cannot determine preoperatively the state of the mucocele, whether filled or empty, and that operation by external approach is necessary to insure permanent intranasal drainage.

Mucocele of the maxillary sinus is much less common than that of the ethmoid or the frontal sinus. De Paula Assis [60] reports a case in which such a tumor in a woman of 29 was removed by the Caldwell-Luc procedure. The symptoms were slight swelling of the cheek, attacks of severe headache, worse when chilled, and a sensation of fulness. Roentgenograms showed marked cloudiness. The Caldwell-Luc operation revealed a sinus filled with a yellowish green gelatinous mass. Histologically it was composed of masses of mucus mixed with blood and epithelial cells.

One of the 3 tumors reported by Weaver [61] occurred in a woman of 38, who gave a history of repeated nasal hemorrhages from the right side of the nose over a period of a year. Biopsy of antral mucosa obtained through a Caldwell-Luc incision was reported to show chronic inflammation with edema. Bleeding was observed from the region of the ethmoid bulla, and biopsy of tissue from this region was reported as showing capillary hemangioma. The middle turbinate was removed, the ethmoid cells were cleaned out and the Caldwell-Luc operation was performed. Although no further evidence of the growth was found in the tissue thus removed, a 50 mg. capsule of radium was placed in the operated field. There were no recurrences of the bleeding.

Monteiro [62] reports 3 cases of fibroma of the maxillary sinus in which the symptoms were not notable until the mass became large enough to erode the bony walls and present an external swelling. The diagnosis could not be definitely determined until surgical exposure revealed a fairly hard smooth mass, which in 1 instance was easily separated and in the others was more or less densely attached. Recurrence was not noted for periods of from eleven to twenty years. The author states that correctness of the preoperative diagnosis may be assumed when roentgenograms show a solid, well defined tumor with erosion of the bony walls of the sinus. The prognosis is generally good.

Myxoma of the nasal cavities is rather rare. The one reported by Richter [63] occurred in a man of 71, whose complaints were nasal obstruction and lacrimation. The inferior turbinate on the affected side was cyanotic, and there appeared to be a mass in the posterior part of the inferior meatus. Roentgenograms showed unilateral clouding of the sinuses. An irrigating cannula met with spongy resistance, which interfered with the procedure. The Denker operation was done, revealing absorption of the external wall of the antrum by a smooth mass which was easily shelled out of the sinus. The mass had filled the entire antrum and encroached on the ethmoid cells and the nasoantral wall, to which it was attached by a small pedicle. It measured approximately 5.5 by 5 cm. Histologic sections showed typical myxoma as defined by Eckert-Möbius. The epithelial covering was very thin, and beneath a moderate subepithelial layer was a tumor mass consisting of numerous stellate cells enclosing a homogeneous ground substance. The latter was principally mucin, as proved by specific stains.

### SURGERY

Simpson [64] well expresses the confusion that exists in the minds of some rhinologists with reference to the application of surgery to sinus disease in view of conflicting statements frequently found in the literature. However, he finds that the trend is not so much toward extreme conservatism vs. radical measures as to intelligent appraisal of the individual patient. In acute sinusitis surgical intervention is indicated under the following conditions: (1) spreading osteomyelitis complicating acute infection of the frontal or the ethmoid sinus, (2) orbital abscess,

58. Weaver, D. F.: Dentigerous Cyst of the Maxillary Antrum, Ann. Otol., Rhin. & Laryng. **52**:516 (June) 1943.

59. McNally, W. J.; Stuart, E. A., and Childe, A. E.: Mucocele of the Frontal Sinus: Report of Five Cases, Arch. Otolaryng. **38**:574 (Dec.) 1943.

60. de Paula Assis, J. E.: Mucocele do seio maxilar, Rev. brasil. oto-rino-laring. **10**:627 (Nov.-Dec.) 1942.

61. Weaver, D. F.: Three Unusual Cases of Hemangioma, Ann. Otol., Rhin. & Laryng. **52**:507 (June) 1943.

62. Monteiro, A.: Fibroma do seio maxilar, Hospital, Rio de Janeiro **23**:19 (Jan.) 1943.

63. Richter, H.: Ueber ein Myxoma der Oberkieferhöhle, Arch. f. Ohren-, Nasen- u. Kehlkopfh. **151**:351, 1942.

64. Simpson, J. R.: Indications for Sinus Surgery, Pennsylvania M. J. **46**:692 (April) 1943.

(3) frontal sinusitis that fails to drain under conservative treatment and is accompanied by severe pain, (4) intracranial complications and (5) thrombosis of a cavernous sinus with origin in a paranasal sinus.

The indications in chronic sinusitis present too long a list for this review but comprise in the main those conditions which have failed to yield to adequate conservative treatment as well as those which are definitely of etiologic significance in the persistence of associated pathologic processes in other parts of the body.

Hollender's [65] article is reprinted from a journal in which it was published in 1942,[66] from which it was abstracted in last year's review.

Stahl, Voorhees and Davol [67] made a survey of 100 cases of maxillary sinusitis, in 50 of which the patient had been treated by the Caldwell-Luc operation and in 50 of which treatment had been by intranasal antrostomy, with the object of determining the end results. Evaluation was attempted on the basis of the following five points: (1) symptoms, (2) responses to a questionnaire, (3) irrigation, (4) antroscopy and (5) roentgen evidence. It was found that the first two points were inadequate and had to be discarded. Also, antroscopy failed to yield the desired information. Furthermore, it was found that in the cases in which the patient was subjected to the radical operation subsequent roentgen studies revealed a dark antrum which was difficult to interpret. Consequently, the only criterion of any consistent value in their experience was the irrigation, a persistently clear wash being taken as an indication of the absence of infection. This evidence of cure was obtained in 54 per cent of the Caldwell-Luc series and in only 26 per cent of the antrostomy series.

The authors conclude that their failures were due to (1) mistaken diagnosis, (2) failure to eliminate adjacent foci of infection, (3) inadequate antrostomic opening, (4) failure to correct preexisting anatomic defects and (5) improper technic. They believe that the indications for surgical treatment are relative rather than absolute.

Neto [68] has a few words to say in favor of endonasal antrostomy, citing a number of articles in the literature. He recommends it because of its simplicity in cases in which adequate drainage cannot be obtained by puncture and irrigation, in the case of children to avoid possible danger to the tooth buds and in many other cases to avoid more radical procedures.

Cora Eliseht [69] describes a combination trocar-rasp for making an endonasal opening into the antrum, with details of its use. It has a pointed end for perforating the nasoantral wall, and the rasp portion is curved so that the bone may be filed down in all directions.

Walsh [70] operated on the frontal sinuses of dogs (22 sinuses in all), using three different technics, and observed the healing process directly and by postmortem examination. The three technics were as follows: (1) enlargement of the ostium and the nasofrontal duct, (2) radical removal of the membrane of the frontal sinus with enlargement of the ostium and the nasofrontal duct and (3) radical removal of the mucosa of the frontal sinus to within one-fourth inch (about 0.5 cm.) of the leaf and ostium but without interference with the leaf, the ostium or the nasofrontal duct. He found that the operation yielding the best results was the one in which the leaf and the nasofrontal duct were not traumatized. The operations in which the leaf and the mucosa of the duct were destroyed resulted in subsequent scar contraction with obstruction to drainage and retention of secretion.

The author performed his operation (no. 3) on 3 patients and reports prompt healing with disappearance of the symptoms. The sinus was opened through the floor and all the membrane removed down to within one-fourth inch of the ostium. A small rubber drain was left at the inner angle of the wound for twenty-four hours.

Walsh describes the leaf as a thin lamella of bone covered with mucosa and lying mesial to the ostium. The mucosa on the side facing the ostium is richer in goblet cells and vessels than the mucosa on the other side.

Alves [71] constructed a prosthesis of vulcanite to cover a deformity of the supraorbital margin following a Riedel operation for extensive complicated frontal sinusitis. The prosthesis was colored to match the skin and was attached by a bar to a pair of dark eyeglasses. The patient had refused to undergo a plastic procedure.

65. Hollender, A. R.: Nasal and Sinus Surgery, Eye, Ear, Nose & Throat Monthly **22**:21 (Jan.) 1943.

66. Hollender, A. R.: Nasal and Sinus Surgery: Critical Review of Causes of Unsuccessful End Results, South. M. J. **35**:363 (April) 1942.

67. Stahl, R. H.; Voorhees, D. G., and Davol, R. T.: A Survey of Antral Surgery: Review of One Hundred Cases, Laryngoscope **53**:186 (March) 1943.

68. Neto, L. P.: Cirurgia endonasal nas sinusites maxilares, Rev. paulista de med. **22**:132 (Feb.) 1943.

69. Cora Eliseht, F.: Abertura endonasal del seno maxilar con el trocar-Lima, Rev. brasil. de oto-rino-laring **10**:623 (Nov.-Dec.) 1942.

70. Walsh, T. E.: The Role of the Ostium and Nasofrontal Duct in Postoperative Healing, Laryngoscope **53**:75 (Feb.) 1943.

71. Alves, O.: Prótese orbitária nas complicações sinusais na técnica de Riedel, Arq. de cir. clin. e exper. **6**:322 (April-June) 1942.

Berendes and Heidenreich [72] analyze 12 cases of tumor of the pituitary gland from the clinic of K. Beck from the surgical point of view to determine the relative merits of the transsphenoidal and the frontal approach. Their conclusions are as follows: 1. Adenoma can be dealt with through the frontal approach, whereas craniopharyngioma is not so accessible because of adhesions to the cranial base. 2. Operative mortality in cases of intrasellar adenoma is about the same with either method, and in cases of craniopharyngioma the frontal approach is more risky than the transsphenoidal. 3. The survival period is longer if adenoma is operated on transfrontally. 4. The transsphenoidal operation is indicated if the tumor is inoperable, particularly if it is a cyst, for the relief of pressure and to afford access for the application of radium.

Welsh [73] recommends Hirsch's transseptal approach for the intrasellar tumor with implantation of radium as a simple palliative measure in those cases in which an intracranial surgical operation is not feasible. He reports 5 cases. The amount of local irradiation should not exceed 1,000 milligram hours. The author comments on the fact that this procedure does not interfere with subsequent use of high voltage roentgen rays or transfrontal surgical removal.

### NONSURGICAL THERAPY WITH DRUGS

Jackson [74] describes a number of experiments on anesthetized dogs in which the effects of various vasoconstrictor and vasodilator drugs on the nasal mucosa were recorded by means of an apparatus which measured the volume of air in the nasal chambers and sinuses. The blood pressure and the respiration rate were noted simultaneously. Aside from demonstrating the action of such well known drugs as epinephrine, nicotine, ether sodium nitrite, pentobarbital sodium and histamine, the author discusses the probable explanation of alternating nasal obstruction affecting the dependent side when the patient lies first on one side and then on the other. He seems to think that it is most likely due to pressure on the innominate veins by the weight of the organs within the chest, although other possibilities are also mentioned.

The article contains many valuable data which, though primarily pharmacologic, are nevertheless highly pertinent to the practical application of many of the drugs commonly employed.

Fabricant [75] reviews most of the recent literature on the effects of the local use of sulfonamide drugs and concludes that indiscriminate use of these drugs is not without danger. He points out that there are numerous factors to be considered, such as the effect of the drug on the ciliated epithelium, the relationship to intranasal $p_H$, the degree of toxicity and the possibility that a resistant state may develop. While conceding the value of the newer combinations of sulfonamide compounds and a vasoconstrictor in certain limited fields, he holds that their wider application should be restrained pending the development of the ideal preparation, which would be nontoxic under all conditions and entirely compatible with nasal physiology.

Dolowitz, Loch, Haines, Ward and Pickrell [76] continued the clinical investigation on the effects of sulfadiazine in a 2.5 per cent concentration in an ethanolamine spray for the prevention of colds which was started by Crowe and his associates and reported elsewhere.[77] A group of 59 patients received the treatment; 44 were treated with ethanolamine only, and 183 who received no prophylactic therapy were studied for the incidence of complications of the common cold. The incidence of such complications as sinusitis, otitis media, laryngitis and cough was definitely much less in the group who used the sulfadiazine spray. In fact, none of this group had sore throats as against a 10 and 12 per cent incidence in the other two groups. Daily cultures from the nasopharynx and the pharynx revealed disappearance of beta hemolytic streptococci within twenty-four hours. Pneumococci and staphylococci persisted longer, but their virulence was greatly attenuated if one may judge by the clinical course and the absence of complications.

Turnbull, Hamilton, Simon and George [78] state that they observed the effects of a stable sodium

72. Berendes, J., and Heidenreich, F. J.: Zur Klinik transsphenoidal operierter Hypophysentumoren, Arch. f. Ohren-, Nasen- u. Kehlkopfh. **151**:332, 1942.

73. Welsh, T. F.: Trans-Septal Sphenoid Approach with Implantation of Radium to Pituitary Fossa as Treatment for Adenomatous Tumors of the Pituitary Gland, Laryngoscope **53**:724 (Nov.) 1943.

74. Jackson, D. E.: Experimental and Clinical Observations Regarding the Physiology and Pharmacology of the Nose, Ann. Otol., Rhin. & Laryng. **51**:973 (Dec.) 1942.

75. Fabricant, N. D.: The Local Use of Sulfonamides in Nasal and Sinus Infection: An Analytical Review, Am. J. M. Sc. **206**:546 (Oct.) 1943.

76. Dolowitz, D. A.; Loch, W. E.; Haines, H. L.; Ward, A. T., Jr., and Pickrell, K. L.: The Prevention of Ear and Nasal Sinus Complications of the Common Cold, J. A. M. A. **123**:534 (Oct. 30) 1943.

77. Bordley, J. E.; Crowe, S. J.; Dolowitz, D. A., and Pickrell, K. L.: Local Use of Sulfonamides, Gramicidin (Tyrothricin) and Penicillin in Otolaryngology, Ann. Otol., Rhin. & Laryng. **51**:936 (Dec.) 1942.

*(Footnotes continued on next page)*

sulfathiazole solution combined with dl-desoxyephedrine hydrochloride in over 1,000 cases of infection of the ear, the nose and the throat, including sinusitis, rhinitis, pharyngitis, laryngitis and acute and chronic suppurative otitis media. They encountered six unfavorable reactions, each due, they claim, to an allergic response. They obtained prompt relief from the use of this combination against acute colds and sinusitis, with lessened tendency toward chronicity. Many chronic conditions reacted favorably "where formerly surgery would have been indicated." The authors disclaim any intention of having the drug substitute for surgery in those cases in which "massive pathologic changes of the membrane or bone exist."

The $p_H$ of the solution employed by the authors is given as 8.6 to 9.

Gundrum [79] employed intranasally in rabbits a 4.7 per cent solution of sodium sulfathiazole, sodium sulfadiazine and butanoylsulfanilamide (also 4.7 per cent) and observed that these drugs caused destruction of the mucosa to a greater or lesser degree. He concludes that the reaction was not due to the alkalinity of the solutions used since the $p_H$ of the butanol preparation is 7.3, which is practically neutral. The reactions must therefore have been due to the irritation of the drug itself.

Proetz [80] conducted a number of experiments with 2-aminoheptane and noted that its toxicity as compared with that of ephedrine was 52 per cent. Its $p_H$ is 5.7. A 2 per cent solution failed to inhibit ciliary activity for periods of from forty-six minutes to two hours and fifteen minutes. Clinically a 0.5 per cent solution of 2-aminoheptane sulfate produced the same shrinking effect as a 2 per cent solution of ephedrine sulfate.

In experiments 2-amino-4-methylhexane sulfate produced effects comparable to 2-aminoheptane sulfate in half the strength of the latter. Both solutions were found to be less deleterious to ciliary activity than other vasoconstrictors. After nasal application their action was prolonged and resulted in no rise in blood pressure.

These drugs were not yet available commercially at the time Proetz presented his report. (Comment: They are now available as tuamine 1 per cent and 2 per cent. S. S.)

Butler and Ivy [81] made a study of the effects of inhaled amphetamine and dl-desoxyephedrine on the human nasal mucosa. The experiments were conducted on normal persons by means of an apparatus previously described by Sternstein and Schur, who made a similar investigation. This apparatus measures the degree of nasal patency or obstruction by means of a continuous and predetermined flow of air through one side of the nose, the fall and rise of which are registered on an interposed gage. The amount of volatile drug passing into the nose is controlled and measured by an apparatus devised by Dr. D. L. Tabern, of the Abbott Laboratories. A total of 266 experiments revealed some interesting results. It was found that inhalers of low output caused less congestion after the early constriction had subsided; also that the addition of menthol and other aromatic oils reduced the degree of constriction associated with the pure drug but, on the other hand, prolonged the period of the latter's effectiveness. In both instances the maximum effect was observed in about fifteen minutes. Inhalers containing only menthol and aromatic oils produced only an illusion of nasal patency due to the anesthetic effect of the menthol. Actually their use resulted in congestion and greater obstruction.

Formula 776, containing dl-desoxyephedrine, astrotone (a perfume fixative), the perfume N. W. C. and natural menthol, seemed to yield better results than the pure dl-desoxyephedrine alone, probably because of a lower concentration of the drug in the former and because of the fixing properties of the astrotone, menthol and perfume, which doubtless release the constricting agent more slowly.

A number of interesting experiments were conducted by a group at the Johns Hopkins Hospital [82] to determine the effectiveness of penicillin and tyrothricin employed locally in infected areas about the ear and the nasal cavities. Cultures of various bacteria on blood agar were exposed to various dilutions of these compounds, by which it was shown that streptococci are more resistant than pneumococci and that "staphylococci, of all gram-positive organisms, are most resistant to the action of tyrothricin and penicillin." Certain strains were found to be more

78. Turnbull, F. M.; Hamilton, W. F.; Simon, E., and George, M. F., Jr.: Sinusitis and Infections Secondary to Common Cold, J. A. M. A. **123**:536 (Oct. 30) 1943.

79. Gundrum, L. K.: Effect of the Newer Sulfanilamide Derivatives on the Nasal Mucosa of Rabbits, Arch. Otolaryng. **37**:209 (Feb.) 1943.

80. Proetz, A. W.: Certain Aliphatic Compounds as Nasal Vasoconstrictors, Arch. Otolaryng. **37**:15 (Jan.) 1943.

81. Butler, D. B., and Ivy, A. C.: Effects of Nasal Inhalers on Erectile Tissues of the Nose, Arch. Otolaryng. **38**:309 (Oct.) 1943.

82. Crowe, S. J.; Fisher, A. M.; Ward, A. T., Jr., and Foley, M. K.: Penicillin and Tyrothricin in Otolaryngology, Ann. Otol., Rhin. & Laryng. **52**:541 (Sept.) 1943.

sensitive than others, and individual strains, resistant to one and sensitive to the other.

Tyrothricin, having a strong hemolytic action, cannot be used intravenously or subcutaneously but, on the other hand, exerts a powerful influence over certain bacteria when applied locally. It is of greatest value when employed immediately after operation in an infected locality, by virtue of its power to destroy surface bacteria. Penicillin, being more soluble, has greater penetrating qualities and is therefore of value in more prolonged infections, in which the bacteria are more deeply located within the tissues.

Several series of cases are cited. One group of 10 cases revealed the effectiveness of these compounds in combating Staphylococcus aureus infection of sinuses and the mastoid process. The operative wounds were irrigated and packed with gauze saturated with a 1:10,000 solution of tyrothricin. Later both tyrothricin and penicillin solutions were used by irrigation, and despite extensive involvement of bone and soft tissues, prompt recovery was obtained in this group of cases. On the other hand, in a group of 6 cases in which the same organism was isolated and the same therapy followed the results were disappointing, probably because the particular strain was resistant. A group of 7 cases in which the infective organism was Streptococcus yielded excellent results from the use of tyrothricin and penicillin. The results in a group of 6 cases of infection with Pneumococcus were equally gratifying.

The authors emphasize the following points: The local use of the sulfonamide compounds as a routine postoperative measure should be discouraged because of their poor solubility and the tendency to act as a foreign body. Furthermore, patients have been known to become sensitized to these drugs so that if the drugs were subsequently employed to combat pneumonia, meningitis or other grave infections, severe toxic reactions resulted. Tyrothricin is not soluble and does not penetrate into the blood stream when used locally. It is therefore safe as a local remedy and is of value in preventing wound infection because of its action on superficially located bacteria.

The cases cited by the authors include cases of sinus infection with complicating orbital abscess, cases of osteomyelitis with operation on the frontal, ethmoid and maxillary sinuses and cases of mastoiditis with operation.

Rusk and Van Ravenswaay [83] present a résumé of their results in a controlled study of 670 cases of simple infection of the upper respiratory tract. Sulfadiazine was given in one group, capsules containing acetylsalicylic acid 3½ grains (0.22 gm.), acetophenetidin 2½ grains (0.16 gm.) and caffeine ½ grain (0.032 gm.) in another group and powder of ipecac and opium N.F. in a third. All patients were given supplementary supportive treatment with fluids, gargles and intranasal medication. Analysis of their results reveals no particular difference in favor of the use of sulfonamide drugs.

Sulman [84] reports on the use of a 1 per cent aqueous solution of paredrine hydrobromide (P-hydroxy-α-methylphenethylamine hydrobromide) to which microcrystals of sulfathiazole were added in the concentration of 5 per cent, in 75 cases of acute and chronic sinusitis of nonallergic origin. The procedure after simple shrinkage was to introduce the solution by instillation, packing or displacement. The home treatment consisted of dropping the solution into the nose two to four times daily. The author claims the treatment was successful in reducing nasal congestion and decreasing the discharge without apparently damaging the cilia. He believes the course of the infection was shortened and that sequelae were averted. The Proetz method was employed mainly with infants and young children, and, according to a table of 23 cases, the good results were obtained in a period of from one to eight days.

Ebert [85] found the insufflation of sulfathiazole powder an effective treatment for acute rhinitis. By actual measurement he determined that the amount which the patient received in this manner was infinitesimal in comparison with the customary oral dose; it averaged 0.0164 Gm. in each nostril at each treatment. The powder was blown into the nose once a day for the duration of the attack, which he states averaged three to five days. No untoward effects were observed either subjectively or objectively. He states, however, that the other procedures in vogue for the treatment of acute rhinitis were carried out, with the exception of the use of nose drops, which he decries.

Stovin [86] reports good results from the use of sulfallantoin, a loose addition product of sulfanilamide and allantoin (glyoxyldiureide, which is a urea derivative), in both acute and chronic

83. Rusk, H. A., and Van Ravenswaay, A. C.: Sulfadiazine in Respiratory Tract Infections, J. A. M. A. **122**:495 (June 19) 1943.

84. Sulman, L. D.: Paredrine Hydrobromide-Sulfathiazole Therapy of Infections of the Upper Respiratory Tract, Arch. Otolaryng. **37**:713 (May) 1943.

85. Ebert, E.: Local Treatment of Acute Rhinitis with Sulfathiazole, Arch. Otolaryng. **38**:324 (Oct.) 1943.

86. Stovin, J. S.: Nasal Therapy with Special Reference to Sulfonamide Compound, Eye, Ear, Nose & Throat Monthly **22**:175 (May) 1943.

sinusitis. Ten cases are cited, mostly cases of chronic maxillary sinusitis with positive evidence from roentgen examination and irrigation. Improvement was noted after the solution had been introduced into the sinus by instillation or by displacement. The solution employed was hypertonic and acid; the $p_H$ was 5.4.

Littell [87] used sodium sulfathiazole in the form of a spray to cover the denuded areas in the nasal chambers following ethmoidectomy in 99 of 128 patients. It was rarely necessary to employ packing, and he believes the procedure not only contributed much to the patients' comfort but reduced the degree of postoperative reaction and controlled the granulations.

Means [88] claims good results from the use of "acolloidal calcium gelatinate" solution in chronic sinusitis. The solution is used in the form of drops, with the head in the Proetz position. He reports complete relief in 52 per cent of the patients treated by specialists and 68 per cent of those treated by physicians in general practice.

Riera, Schouten and Grau [89] report on the local use of an antivirus in several cases of chronic sinusitis, mostly involving the antrum. In the few cases cited the results were excellent. Pain, discharge and olfactory disturbances disappeared after five or six treatments. The antivirus was made according to the Besredka technic and was applied within the nose on tampons, which were left in place for one to two hours.

Cowan, Diehl and Baker [90] conducted experiments in a group of university students on the clinical value of large doses of vitamin C and of large doses of mixed vitamins in the prevention of colds. There were 427 students in the "cold prevention group," and 183 were given 100 mg. tablets of ascorbic acid to be taken two a day for twenty-eight weeks. Fifty others were instructed to take two a day for the first two weeks and then one tablet daily throughout the rest of the period, unless interrupted by a cold, when they were to take five tablets daily for the first two days, after which they were to take one tablet per day. As a control group, 194 students were given placebo tablets of the same size and shape, taste and appearance with instructions to take two tablets daily. A similar test was conducted with a group of 347 students taking capsules containing a mixture of vitamins A, B, $B_2$ C and D, two per day throughout the "cold season." It was observed that neither the ascorbic acid nor the mixture of vitamins exerted any appreciable effect on the incidence or the severity of infections of the upper respiratory tract in the treated groups as compared with the control group.

De Groot and Melvin [91] report successful results from ionization in the treatment of chronic sinusitis. Cotton moistened in a 2 per cent solution of mild silver protein placed in the nose was connected to the positive pole. The negative or indifferent electrode was a large pad 3 by 5 in. (7.5 by 12.5 cm.) placed under the back. From 5 to 10 milliamperes of current was used for ten to fifteen minutes in each side of the nose. Treatments were given three times weekly for one to three months, then less frequently up to six months. The immediate result of the treatment was a free discharge of mucus, followed by easier breathing and relief from headaches. No details are given as to the type or the location of the sinus disease or the approximate extent of the pathologic changes.

Littell [92] has obtained good results in chronic maxillary sinusitis from the use of 27 per cent iodized and 7.5 per cent chlorinated peanut oil in 50 per cent combination with oil of sesame, which he instilled through the middle meatus. The good results were particularly apparent in the vasomotor and suballergic types of infection and are attributed to the stimulating effect of the iodine on the mucous membrane as well as to a possible effect on the thyroid gland by absorption.

Goodale [93] presents a résumé of some important articles on sinusitis that appeared during the previous year, with emphasis on those points which he thinks worthy of particular mention.

Bowers' [94] article is a republication of an article previously published in the *Bulletin of the New York Academy of Medicine,* from which it was abstracted in the review for 1942.[95]

87. Littell, J. J.: Undiluted Sulfonamide Drugs in Sinus Surgery, J. Indiana M. A. **36**:250 (May) 1943.

88. Means, R. N.: Treatment of Sinus Disease with Colloidal Calcium Gelatinate, M. Rec. **156**:222 (April) 1943.

89. Riera, J.; Schouten, G. B., and Grau, D.: Sobre el tratamiento biologico de las sinusitis, Arq. de biol. **27**:68 (May-June) 1943.

90. Cowan, D. W.; Diehl, H. S., and Baker, A. B.: Vitamins for the Prevention of Colds, J. A. M. A. **120**: 1268 (Dec. 19) 1942.

91. De Groot, A., and Melvin, G. M.: The Treatment of Chronic Sinusitis by Silver Ion Transfer: A Preliminary Report, M. Bull. Vet. Admin. **19**:433 (April) 1943.

92. Littell, J. J.: Treatment of Chronic Sinusitis with Iodized Oil, Arch. Otolaryng. **37**:723 (May) 1943.

93. Goodale, R. L.: Treatment of Sinusitis, New England J. Med. **229**:622 (Oct. 14) 1943.

94. Bowers, W. C.: Present Day Treatment of Infections of the Middle Ear and Nasal Sinuses, Eye, Ear, Nose & Throat Monthly **22**:293 (Aug.) 1943.

95. Bowers, A. C., cited by Salinger, S.: The Paranasal Sinuses, Arch. Otolaryng. **36**:393 (Sept.) 1942.

### NONSURGICAL THERAPY WITH ROENTGEN RAYS

Crang [96] is convinced of the value of roentgen rays in the treatment of sinusitis and states that the best results are obtained when the case is properly studied by cooperation of the roentgenologist with the rhinologist. Roentgen therapy is indicated particularly when the disease is subacute since this is the stage in which the changes in the mucosa have not advanced too far and are capable of prompt resolution. Chronic sinusitis in which simple hyperplasia is present without involvement of the bone and before fibrosis has taken place is also amenable. The author uses 135 kilovolts, with 0.25 mm. of copper and 1 mm. of aluminum as filter, and a distance of 40 cm., and gives 100 r in air twice a week for four or five treatments. He has treated 57 patients and lists his results as follows: excellent in 46 per cent, fair in 14 per cent, poor in 40 per cent.

Haines [97] claims excellent results from roentgen treatment in over 100 cases of sinusitis. No mention is made of rhinologic diagnosis, the therapy apparently having been administered on the basis of roentgen findings. He delivers 150 r over the face and repeats the treatment in a week if necessary. The author has noted an increase in the symptoms immediately after the first treatment; the symptoms usually abate before the third exposure. Four treatments constitute the entire procedure.

### CLINICAL CONSIDERATIONS AND OBSERVATIONS

Goldsmith [98] presents a general outline of the physiologic factors which make up the defense mechanism of the nose and the sinuses and discusses the elements which bring on the various conditions of the sinuses. He comments on the situation and complexity of the ethmoid labyrinth and the diagnostic problems involved. His criteria of the value of roentgen rays and transillumination in diagnosis are sound and reflect the generally accepted standards. He is not enthusiastic about treatment of the sinuses as foci of infection in general medicine and claims that his point of view is amply confirmed by statements on the part of a number of specialists of highest repute.

The author maintains an open mind on the question of the local use of sulfonamide compounds but is firmly convinced of their value in combating severe complications. He decries the use of strong medicaments in the nose, relying entirely on ephedrine in the strength of 1 per cent when a nasoconstrictor is indicated. In cases of subacute and in some cases of chronic sinusitis he has had good results from irrigations, using calamine liniment B. P. and a small amount of watery solution of acriflavine B. D. H.

Russell [99] refers to the works of Yates, Le Gros Clark and Sluder in discussing certain types of nonsuppurative sinusitis which give rise to mental and ocular disturbances. He believes that in many cases the disease is allergic in origin and that in others it is due to deep-seated retention of streptococci. The symptoms which he lists in this connection are pains in the eye, behind the mastoid process, in the gums and in the infraorbital region, suboccipital headaches, difficulty in focusing, paranoia, cancer phobia and mental confusion. The local findings are homolateral edema of the posterior border of the septum, dilatation of the vessels of the mucosa in the posterior superior nasal passages, secretion in the ethmosphenoid recess and roentgen findings, particularly with contrast mediums.

In a study of 151 necropsies Whitaker [100a] was surprised to note a high incidence of chronic sinusitis (86, or 57 per cent), with the ethmoid cells more frequently involved than the others. The figures are broken down into various groups according to age, sex and cause of death. The greater portion of this long treatise, however, is given over to a discussion of the natural means of defense against infection which are inherent in the tissues and to consideration of methods whereby they may be enhanced. Reasoning by analogy with respect to the peritoneal response to irritation in the form of a rush of leukocytes to the threatened area, the author believes that this mechanism, which is manifest in the sinuses during an acute infection, is absent or ineffective in chronic disease and needs to be stimulated if recovery through natural processes is to be achieved. He claims that chronicity is not to be charged against impaired drainage but to failure of leukocytic reaction of sufficient degree to combat the infection. He recommends that a 10 to 20 per cent solution of potassium iodide, a 3 per cent solution of silver nitrate or a 10 per cent solution of sodium nucleinate be introduced into the nasal passages after preliminary cocainization and then aspirated into the affected sinuses

96. Crang, C. L.: An Evaluation of Roentgen Therapy in Disease of the Paranasal Sinuses, Canad. M. A. J. **49**:117 (Aug.) 1943.

97. Haines, F.: Roentgen Ray Therapy of Paranasal Sinuses, South. M. J. **36**:489 (July) 1943.

98. Goldsmith, P. G.: Accessory Sinus Disease in General Practice, Canad. M. A. J. **48**:426 (May) 1943.

99. Russell, H. G. B.: Trastornos de los senos, Rev. oto-neuro-oftal. **17**:148 (Aug.) 1942.

100. (*a*) Whitaker, J. G.: Sinusites e defesas naturais, Rev. brasil. oto-rino-laring. **10**:485 (Sept.-Oct.) 1942. (*b*) Salinger, S.: The Paranasal Sinuses, Arch. Otolaryng. **32**:341 (Aug.) 1940; (*c*) **34**:358 (Aug.) 1941.

according to the method described by Ermiro de Lima, which was abstracted in the review for 1939 [100b] and again in an article by Cora Eliseht, cited in the review for 1940.[100c] Whitaker's article contains illustrations showing the patient pinching the nostrils during the act of aspiration while holding the head in various positions to enable the fluid to be sucked into the desired sinus. He also recommends ionization, the positive electrode being placed either in the middle meatus, in the canine fossa or on the anterior wall of the sphenoid sinus according to the sinuses to be treated, while the negative electrode is placed over the face or the neck.

The author further discusses the value of chemotherapy, short wave diathermy and radiotherapy, citing statistics to support his claim for their efficacy. For instance, in a series of 121 patients treated with roentgen rays 79 (65 per cent) were cured, according to the author. He claims that there is no such thing as natural immunity to sinusitis but that rhinologists should pay attention to the patient's habits, which may be conducive to prolongation of an infection. Among others, he mentions imbalance in diet, such as an excess of spicy foods, a lack of fruits and vegetables and an excess of carbohydrates, as well as very hot or very cold baths.

Hollender [101] presents a résumé of the general therapy of acute infections of the upper respiratory tract, dividing the methods into three groups, namely, prophylactic, abortive and active. He recommends taking vitamin C in 100 mg. doses three times daily in the acute stage, plus mild catharsis and rest in bed. A variety of other measures are suggested in the active treatment, most of which are generally employed.

Hutchison [102] stresses the trend toward conservatism in therapy and specifies his method of handling various types of sinusitis. For instance, in the condition he terms "acute catarrhal sinusitis," in which the patient suffers from severe frontal headaches only in the forenoon, he advises rest in bed, hot fomentations, the use of ephedrine in the nose, avoidance of smoking and forcing of fluids. Diathermy is also helpful. In regard to acute suppurative sinusitis he advises against irrigation of the antrum in the early stages. He reports dryness of the throat in patients using solutions of sulfathiazole but recommends instillation of 5 cc. of soluseptazine (the sodium salt of 4-sulfonamidophenyl-gamma-disulfonic acid) following irrigation.

Chase [103] stresses the importance of a carefully taken history and a detailed examination of every patient as extremely important in the diagnosis. All the various well known procedures are described, with emphasis on the discovery of slight deviations from the normal as important clues in the diagnosis.

Dowdeswell [104] discusses the role of the sinuses in the typical "common cold" or so-called influenza, particularly the recurring type. A study of a group of 60 patients with common colds yielded some interesting data showing that approximately one third of them gave definite evidence of having chronic sinusitis. Bacteriologic examination yielded a variety of organisms in which Pneumococcus, Staphylococcus aureus, Streptococcus viridans and Pfeiffer's bacillus predominated. It was interesting to note that in several patients with recurring colds the same organism was recovered at different times. The chief points to the author's argument are these: Recurring colds are frequently an indication of preexisting chronic sinusitis, and the condition is as prevalent in children as in adults.

An article by Silvers [105] written for the layman gives a fairly accurate account of the nose from the standpoint of physiology and of sinusitis from that of etiology. However, like many other articles appearing in the lay press, it tends to overemphasize certain features to the detriment of others, thus sowing the seed of misconceptions which prejudice the reader. For example, in this paper the statement is made that "today we no longer need fear disfiguring facial operations when sinus disease is diagnosed."

Proetz [106] examines the subject of headache from the point of view of the rhinologist and presents a practical plan whereby the diagnosis may in many cases be arrived at without subjecting the patient to a round of visits to specialists covering all fields of medicine. He believes that it is possible in the beginning to assign the case to one of three categories, namely, "definitely demonstrable causes," "semidemonstrable or suggestive causes" and "undemonstrable causes," most of which are listed. As an aid to determination of category he presents (1) several charts on which are to be noted every fact obtainable from the history bearing on the character, the location, the duration, the intensity and other features of the headache and (2) a

101. Hollender, A. R.: Treatment of Acute Infection of the Upper Respiratory Tract, Eye, Ear, Nose & Throat Monthly **22**:213 (June) 1943.

102. Hutchison, K.: The Sinus Problem, Canad. M. A. J. **48**:431 (May) 1943.

103. Chase, W. D.: Rhinological Responsibility, Eye, Ear, Nose & Throat Monthly **22**:143 (April) 1943.

104. Dowdeswell, R. M.: Sinusitis and the Common Cold, Lancet **2**:763 (Dec. 26) 1942.

105. Silvers, L. J.: Your Sinuses and Your Health, Hygeia **21**:104 (Feb.) 1943.

106. Proetz, A. W.: The Practical Management of Headache, Ann. Otol., Rhin. & Laryng. **52**:409 (June) 1943.

chart listing the foods and dermal stimuli with which the patient may come in contact. The latter the patient is to fill out over a period of time. Information thus obtained frequently offers leads which may be helpful in the diagnosis. The author makes the significant statement that less than 5 per cent of headaches are referable to the sinuses and that sinusitis and headache may be present in the same patient and be totally unrelated.

Since a great many headaches come within the category of idiopathic or undetermined cause, he feels that in regard to these one may experiment with the theory of vascular origin and try the effect of ephedrine and some barbiturate (unless hypertension is present) or that of thyroid with thiamine if fatigue and lassitude are complained of. In order to appreciate the implications of such therapy, it is necessary to read the article in its entirety, as contributig factors, such as the patient's habits with respect to food, drink, tobacco and other things, must be taken into consideration.

Wodak [107] attempts to explain vacuum headaches as being due to the pull exerted by the negative pressure on an inflamed mucosa. He claims that suction will not produce this characteristic pain in a healthy person but rather a sensation of pressure, which is different. In applying suction to the nose for therapy he has noted that as long as secretion is present in the sinus, no pain will be elicited, but that when secretion has stopped and the mucosa is still swollen, the pain can be induced by negative pressure.

Tremble [108] states that frontal headache due to obstruction of the nasofrontal duct may be partly anatomic and partly pathologic in origin. Careful examination and a detailed history are therefore important in the diagnosis. He claims that the obstruction causes edema of the lining mucosa, absorption of air and at times transudation of clear fluid containing albumin and lymphocytes. If the obstruction is due to infection, the history will indicate a typical periodicity and location of the headache. The author suggests the various sulfonamide compounds to use according to the types of infecting organisms. He also mentions headache of sphenopalatine or nasociliary origin which yields promptly to local cocainization.

Blassingame [109] emphasizes the importance of curing subacute maxillary sinusitis as a preventive against chronicity with its possible remote complications. It is important in the waning stages of an acute infection to follow up the condition and remove the last vestige of infection. He has had good results since adopting as a routine the procedure of irrigating the antrum via the natural ostium with various cannulas adapted to different types of nose. In addition to isotonic solution of sodium chloride he has employed iodized poppyseed oil, peanut oil with added chlorine and iodine (iodochloro) and solution of hexylresorcinol, of silver nitrate and of acriflavine at various times. If it becomes apparent that the natural route for drainage is inadequate, he does not hesitate to trephine the nasoantral wall with the Thornwaldt drill, enlarging the opening with a Yankauer forceps to provide an adequate opening for drainage, ventilation and irrigation.

Passos [110] details the history and the course of sporotrichosis of the antrum in a woman of 58. Over a period of years the patient had headaches and pain in the face gradually increasing in intensity until the cheek became swollen and tender. There had always been a free purulent discharge from one side of the nose. Subsequently a fistula developed in the cheek which discharged the same sort of secretion. A probe passed through this opening reached the posterior wall of the antrum, as was shown in the belated roentgenograms. Operation revealed necrosis of the anterior wall of the sinus, which was filled with pus and polypoid mucosa. Following the operation, instead of healing there developed in the external fistula a violaceous area of granulation tissue, which on culture proved to be due to sporotrichosis. Treatment consisting of the administration of iodides and irradiation failed, and the patient succumbed.

Boe [111] reports 3 cases illustrating the relief obtained from irrigating a suspected antrum. One was a case of nocturnal cough; another, of disagreeable postnasal discharge, and the third, of frequent pharyngitis.

### DENTAL FACTORS IN MAXILLARY SINUSITIS

Bauer [112] presents microscopic studies of the antrum and alveolar process in 16 specimens obtained at autopsies to prove that infection of the maxillary sinus may originate from dental and peridental infection without destruction of

107. Wodak, E.: The Headaches of Acute Nasal Sinusitis and an Attempt to Explain Them, J. Laryng. & Otol. **77**:401 (Sept.) 1942.

108. Tremble, G. E.: Headache of Nasal Origin, Canad. M. A. J. **50**:43 (Jan.) 1944.

109. Blassingame, C. D.: Diagnosis and Treatment of Subacute Maxillary Sinusitis, Memphis M. J. **18**:82 (June) 1943.

110. Passos, P.: Sinusite maxilar—sporotricose, Rev. brasil. de oto-rino-laring. **11**:167 (March-April) 1943.

111. Boe, R. A.: Aspects of Suppurative Maxillary Sinusitis, with Case Reports, M. Bull. Vet. Admin. **19**: 465 (April) 1943.

112. Bauer, W. H.: Maxillary Sinusitis of Dental Origin, Am. J. Orthodontics **29**:133 (March) 1943.

the intervening bone. All gradations of pathologic change from localized thickening of the mucosa to extensive infiltration of the mucosa and the periosteum with ultimate fibrosis may be seen in the specimens. The infection may pass from the peridental membrane or the pulp of the tooth to the mucosa of the sinus by way of the rich plexus of vessels which pass through the bone, and roentgenograms may often fail to reveal any dissolution of the osseous tissue. The author is not prepared to state whether the resulting antritis, which in most cases is localized to the immediate vicinity of the affected tooth, gives rise to symptoms, since this is a rhinologic rather than a dental problem. He would like to know whether the pathologic changes within the mucosa of the sinus will disappear after the offending tooth is removed. Certainly the paper is convincing from the histopathologic point of view and is well illustrated with excellent photomicrographs.

Murray and Papesch,[113] having observed a number of cases in which there was a marked thickening of the antral mucosa over the roots of diseased teeth, made an investigation of some 200 cases and discovered that the bacteria in the region of the affected teeth were of the same type as those in the sinus. On the basis of this observation they adopted a surgical procedure which involved removing the diseased tooth or teeth and the alveolar bone that intervenes between these teeth and the antrum, leaving the incision open and treating the antrum by irrigation with hypertonic salt solution. They claim that the wound usually closes spontaneously within three to four weeks.

The article is rather short, and no mention is made as to the pathologic observations within the sinuses in these cases.

Christiansen [114] offers a number of dictums with relation to the treatment of sinusitis of dental origin which are of value to both dentists and rhinologists. He cautions against enlarging a tooth socket for the removal of a tooth from the antrum, against leaving plugs of cotton or gauze in a socket after accidental perforation of the antral floor, against closing a persisting discharging fistula without ruling out sinus disease, which requires an intranasal opening. Also, he advises against attempting to control severe hemorrhage from an antral perforation following an extraction by packing gauze in the socket. He feels that it is much better to open the antrum and expose the bleeding area. In all cases it is important to determine the status of the mucosal lining of the antrum in dealing with any complication arising from the teeth.

Barth [115] presents evidence to refute Voss's [116] contention that there is no such thing as a true antral empyema of dental origin. Voss showed histologic sections from 7 cases in which the antral disease originating in the tooth was localized only in the immediate vicinity of the affected tooth without involving the rest of the sinus. He claimed that in a case in which the entire sinus was affected the disease was rhinogenic in origin, because of involvement of the ethmoid cells. Barth not only cites numerous authorities in refutation of Voss's contention but also offers an analysis of a series of 578 surgical cases, in 71 of which there was evidence of concurrent dental infection. In order further to prove his point, he eliminates all cases of polypoid disease, disease of the ethmoid cells and other possible sources of infection other than dental and still is able to show 42 cases in which the etiologic, clinical, roentgenologic and operative observations prove to be isolated cases of suppuration of an antrum in association with a proved dental focus of infection.

Cipes and Kenyon [117] report their case as one of a dentigerous cyst, although there was nothing in the history or the roentgenograms to indicate such an origin until the pathologic report on the tissue removed was returned. The patient had a discharging alveolar fistula as a result of an incision made over a painful swelling two months previously. The intraoral roentgenograms failed to show an unerupted third molar which was seen in those of the sinus. The Caldwell-Luc operation disclosed the molar tooth high up in the antrum. The mucous lining was degenerated and had to be removed. The authors comment on the inadequacy of intraoral roentgenograms for the diagnosis of cysts and other lesions high up in the coronoid process.

Durbeck [118] advises dentists to remove displaced upper root tips by way of a modified Caldwell-Luc incision which is curved over the bicuspid region with the concavity upward, reflecting a flap upward to expose the intergingival septums. The sinus is entered with a Crane

113. Murray, M., and Papesch, W. C.: The Relation of Dental Disease to Sinusitis, Laryngoscope **53**:366 (May) 1943.

114. Christiansen, G. W.: Treatment of Disease of the Maxillary Antra of Dental Origin, J. Am. Dent. A. **30**:226 (Feb.) 1943.

115. Barth, K.: Ueber dentogene Nasennebenhöhlenerkrankungen, Ztschr. f. Hals-, Nasen- u. Ohrenh. **48**: 144, 1941.

116. Voss, O.: Gibt es ein dentales Kieferhöhlenempyem? Arch. f. Ohren-, Nasen- u. Kehlkopfh. **144**: 113, 1937.

117. Cipes, B. J., and Kenyon, B. B.: Dentigerous Cyst in the Maxillary Sinus Containing an Unerupted Third Molar, J. Am. Dent. A. **30**:835 (June 1) 1943.

118. Durbeck, W. E.: Root Recovery from the Maxillary Sinus, J. Am. Dent. A. **30**:233 (Feb.) 1943.

pick and sufficient bone removed to expose the displaced root. Naturally, he advises that this procedure be in the hands of the dentist only if the sinus is healthy and was healthy at the time of the extraction. Otherwise, the patient should be referred to a competent otolaryngologist.

Wurzel [119] discusses the anatomic relationship between the antrum and the teeth, and the various routes by which the former may be infected from the latter. The article is mainly a plea for careful examination of the teeth for periapical or periodontal disease.

### CLINICAL CONDITIONS ARISING FROM ALTERATIONS OF THE SPHENOID SINUS AND THE FRONTAL BONE

Commander Futch [120] reports an interesting case of plumbism in a man of 34 which was traced to a fragment of a bullet retained within the sphenoid sinus over a period of ten years. In addition to nausea, constipation and aching in the legs and shoulders, there was atrophy in the muscles of the extremities, spasticity, some optic atrophy and brief losses of memory. The fragment was removed by a transseptal approach to the sphenoid sinus, and relief of all symptoms followed promptly.

Goldman [121] reports a case in which a piece of shrapnel striking the left temporal region traversed the upper part of the orbit and lodged in the left sphenoid sinus and the posterior part of the ethmoid labyrinth. It was in there for twenty-two months before being removed. It produced paralysis of the right external and inferior rectus muscles, changes in the right pupil with total blindness in the right eye, bilateral macular retinal degeneration and visual changes in the left eye due to macular degeneration, "with the possibility of the presence of hysteria." The mass was removed intranasally after being localized by means of roentgen rays. It occupied the left sphenoid sinus anteriorly and extended somewhat into the posterior ethmoid region. The anterior wall of the sphenoid sinus was gone, and there was a fair-sized perforation of the perpendicular plate of the ethmoid bone and of the rostrum of the sphenoid bone. Vision returned rapidly, although more completely in the left than in the right eye.

The author explains the involvement of the right eye as being due to extension of the larger left sinus behind the smaller right sinus so that the lesion was brought into relationship to both optic nerves. The rapid return of vision could possibly have been due to a large hysterical element in the case, although the author claims it has also been observed in retrobulbar neuritis, especially that due to sinus disease.

Gerundo and Helwig [122] report a case of hyperostosis frontalis interna in a woman of 65 whose early symptoms were headaches and impairment of speech. Changes in personality, loss of memory and other symptoms followed. The hyperostosis was revealed by the roentgenograms and observed at autopsy. The authors comment on the typical symptoms of Morgagni's syndrome, which appeared in this patient, namely, obesity, hypertension and mental disorders, and discuss the various theories as to the pathogenesis.

### FRACTURES THROUGH THE SINUSES

Calvert's presentation [123] is an extremely timely and important one, being based on observations in a series of 128 cases of skull fracture involving the sinuses; 103 of the patients were treated at a military hospital and 25 were prewar patients of Brigadier Cairns. A comparison between the war injuries and those occurring in civilian life revealed a higher incidence of fractures through the sinuses in the former than in the latter, because they were incurred while traveling at a high rate of speed (on motorcycles, in airplanes). In trying to establish criteria for early or late surgical intervention in such cases the author analyzes the symptoms and observations indicating laceration of the dura, which is the real crux of the situation. While cerebrospinal rhinorrhea and aerocele always mean that the dura has been torn, the absence of these symptoms does not always signify the opposite. Since the records show that laceration of the dura is an indication for early surgical intervention, it is important to establish this fact, because undetected dural laceration treated conservatively is more likely to result in late meningitis or abscess of the brain. The authors' statistics reveal a higher percentage of recoveries following wide exposure with suture of the dura or repair by fascia lata or muscle grafts than following conservative treatment. The procedure advised is as follows: After the external wound has been properly treated by débridement and cleansed and the patient is

119. Wurzel, D.: The Maxillary Sinus and Dental Procedures, Am. J. Orthodontics **29**:623 (Nov.) 1943.

120. Futch, C. E.: Lead Intoxication from a Bullet Lodged in the Sphenoid Sinus and Surgical Removal of the Nidus, J. A. M. A. **121**:580 (Feb. 20) 1943.

121. Goldman, I. B.: Shrapnel in the Sphenoid Sinus Causing Blindness: Removal with Recovery, Laryngoscope **53**:383 (June) 1943.

122. Gerundo, M., and Helwig, G. F.: Morgagni's Syndrome—Hyperostosis Frontalis Interna, M. Rec. **156**:31 (Jan.) 1943.

123. Calvert, C. A.: Discussion on Injuries of the Frontal and Ethmoidal Sinuses, J. Laryng. & Otol. **77**: 499 (Nov.) 1942.

sufficiently recovered from the initial shock, roentgenograms should be taken to establish the diagnosis of the extent of the fracture. The primary operation should be carried out promptly with the region under local anesthesia. All foreign bodies, clots and dead tissue should be removed and the wound dusted with sulfanilamide powder and sutured without drainage. No attempt is made to wash out clots from the nose, and the patient is treated systemically with sulfonamide compounds. As soon as the patient's condition warrants, a thorough roentgen study of the skull and the sinuses should be made to locate the dural tear. Patients with cerebrospinal rhinorrhea should be protected particularly against possible air-borne infection from persons with head colds and other contagious diseases. Aside from rhinorrhea and aerocele, the authors believe that

> . . . X-rays showing a wide gap in the posterior wall of the frontal sinus or any considerable displacement of bone in that region, a fracture running down in the posterior wall of the frontal sinus to the anterior ethmoidal cells and widening rapidly as it descends, a fracture passing from one cranial fossa across the cribriform plate to the opposite half of the base of the skull, a fracture associated with the projection intracranially of a sharp fragment from the back of the frontal sinuses or the medial part of the orbital roof, would all be likely to be complicated by dural laceration and therefore probably best treated by operation. . . . The same applies to the inverted U-shaped fracture resulting from a blow on the side of the head in the region of the base of the external angular process of the frontal bone. The posterior limb of this fracture passes down into the anterior temporal region whilst the anterior limb descends across the forehead to enter the frontal sinus on the same or opposite side, ending in the roof of the orbit. This is a dangerous type of fracture . . .

Tilting of the crista galli or distortion of the roof of the ethmoid labyrinth signify in most cases that there is a laceration of the dura.

Brigadier Cairns, whose previous contributions on this subject have been invaluable, took part in the discussion and recalled several instances in which patients were treated conservatively with primary recovery and at a later period meningitis or abscess of the brain developed as a result of an infection of the upper respiratory tract with invasion via the unrepaired dural tear.

Berendes [124] urges early correction of traumatic deformities affecting the nose, the nasal septum and the sinuses. When they are neglected, the granulations and subsequent scarring may so distort the structures as to make subsequent replacement impossible. In addition to replacing bony fragments and restoring contour, he stresses seeing that the nasal passages are clear and that a fractured and lacerated septum is set right. Injuries of the antrum are less dangerous than those of the ethmoid and frontal sinuses. In such cases not only must the wounds be thoroughly cleansed but all bone fragments and foreign bodies must be removed. In addition, lacerations of the dura should be freely exposed and repaired. The author quotes from "Handbuch der ärztlichen Erfahrungen im Weltkriege" [125] issued after World War I as follows: ". . . penetrating foreign bodies involving the sinuses should be removed at the earliest possible moment. The indication for removal is all the more urgent if infection is present or there is a lesion of the cerebral sinus wall."

Orso [126] reports an unusual case which he saw in 1932. A young man of 22 was struck over the left side of the face by a heavy branch while engaged in chopping down a tree. He was brought in comatose with an extensive laceration of the cheek and side of the nose, a nasal fracture and bleeding from the nose and the mouth. After the clots were removed and the nasal bones replaced, examination revealed a fracture of the anterior wall of the sphenoid sinus running diagonally from above laterally to below medially. The crack was 2 to 3 mm. wide, and there was a free splinter of bone present, removal of which disclosed that the sinus was filled with blood clots. Meningeal symptoms developed, and the spinal fluid was clouded and bloody. The patient was given intravenous injections of methenamine, and after a stormy siege finally recovered. The author states that the man has since served in the army and apparently suffers no ill effects from the accidents.

Hubrich [127] reports a case of depressed fracture of the anterior wall of the maxillary sinus due to a blow with a fist. It caused emphysema of the face in addition to severe bleeding into the nose and conjunctival sac. Roentgenograms taken fourteen days later showed complete absorption of the air with return of the soft tissues to normal but the deformity in the bone was unchanged. No mention is made as to whether any attempt at replacement was made.

Rotter [128] cites several cases in which soldiers sustaining wounds about the face died either in

124. Berendes, J.: Ueber die Notwendigkeit der operativen frührersorgung von Verletzungen der Nase und ihrer Nebenhöhlen, Deut. Militärarzt **7**:579 (Sept.) 1942.

125. von Schjerning, O.: Handbuch der ärztlichen Erfahrungen im Weltkriege, Leipzig, J. A. Barth, 1922.

126. Orso, L.: Ueber eine eigenartige Verletzung des Keilbeines, Monatschr. f. Ohrenh. **76**:483 (Oct.) 1942.

127. Hubrich: 2 Fälle von traumatischem Weichteilemphysem bei Trachealruptur und Oberkieferhöhlenimpressions-fraktur, Röntgenpraxis **14**:336 (Sept.) 1942.

128. Rotter, W.: Ueber die Gefahr der Blutaspiration bei Schädelverletzten, Deut. Militärarzt **7**:232 (April) 1942.

transit to evacuation hospitals or soon thereafter as a result of aspirating blood into the lower respiratory tract. This was proved at autopsy. The author stresses the importance of inspecting the nose and the nasopharynx before a casualty is removed and states that it is absolutely necessary that patients with such injuries be transported with the head hanging and turned to one side. This is particularly important if the patient is unconscious. Incidentally, the author states that the hemorrhages in these cases were not traceable to laceration of any large vessel but rather to numerous capillary hemorrhages arising in the nose and sinuses.

### AEROSINUSITIS

Most of MacKenzie's [129] paper is devoted to a discussion of aero-otitis, which occurs much more frequently than aero-sinusitis. He found by tests in the low pressure chamber that the sinus becomes involved generally in rapid descent from altitudes of 25,000 feet or more. The symptoms are pain in the frontal area spreading to the vertex and eyes and frequently accompanied by lacrimation. Examination fails to reveal anything abnormal within the nose although occasionally there may be a discharge of dark serous fluid. Roentgenograms reveal haziness over the frontal and maxillary sinuses. Treatment is directed to relief of pain and correction of the obstruction. Preventive measures include removal of allergic tendencies and gross obstructions. Aviators must not fly until completely relieved of any acute infection of the upper respiratory tract.

Box [130] discusses the development of pain and other symptoms of sinus involvement in aviators as a result of sudden changes in atmospheric pressure on rapid ascent and descent. He finds that inhalation of the vapor of amphetamine frequently brings dramatic relief through the constricting effect on the mucosa, permitting rapid equalization of pressure within and outside the sinus.

Chester and Drooker [131] have found aerosinusitis much less frequent among aviators than aero-otitis and devote the major portion of their paper to the latter topic.

### THE ALLERGIC FACTOR

In an attempt to determine whether the allergic sinus is more susceptible to bacterial infection than the nonallergic, Frank, Blahd and Howell [132] made some experiments on 19 rabbits. These animals were sensitized by four or five intramaxillary injections of a 5 per cent solution of egg white in conjunction with agar at five day intervals, following which various amounts of a highly virulent culture of Pneumococcus were injected. A number of control animals were similarly infected. All the animals were killed and the mucosa of the sinus studied. These histologic studies failed to reveal any difference in degree of reaction between the allergic and the nonallergic animals.

Shambaugh [133] states that in a large proportion of patients suffering from chronic nasal disease the allergic factor is responsible for the continuation and recurrence of symptoms. He describes the differential diagnostic points between a purely infective sinusitis and one in which the allergic factor is the principal offender. The diagnosis depends not only on the results of local examination and patch tests but also on the history and above all on the therapeutic test.

The author holds that the rhinologist should be his own allergist since therapy must often combine the usual rhinologic procedures with treatment for the allergy. In his experience the tests with inhalants are more reliable than those with foods. Treatment consists in eliminating the offending allergen from the diet and in the case of the inhalants injecting it for desentization. He finds that small doses of solutions of house dust in high dilution are more effective than the large doses usually employed. A number of illustrative cases are described.

Rhodes [134] notes that frequently during an acute attack of an infection of the upper respiratory tract superimposed on an allergic background the cytologic examination is deceptive because a marked increase in neutrophils may overwhelm the eosinophils, thus obscuring the picture. In such cases it is extremely important to obtain an accurate history of previous attacks of hay fever, grass fever or other manifestations of allergy. The indications for treatment in such cases are for palliative measures until the acute symptoms have subsided, when active therapy directed to the elimination of the allergy should be undertaken.

129. MacKenzie, J. G.: Otitic and Sinus Barotrauma, Canad. M. A. J. **49**:301 (Oct.) 1943.

130. Box, N. E. H.: Occupational Conditions of the Ear and Nose in Airmen, M. J. Australia **2**:126 (Aug. 14) 1943.

131. Chester, L., and Drooker, J. C.: Aero-Otitis Media and Aero-Sinusitis, Laryngoscope **53**:203 (March) 1943.

132. Frank, I.; Blahd, M., and Howell, K. M.: The Reaction of the Normal and the Allergic Sinus to Virulent Pneumococci, Ann. Otol., Rhin. & Laryng. **52**:80 (March) 1943.

133. Shambaugh, G. E., Jr.: Nasal Allergy, J. Michigan M. Soc. **42**:441 (June) 1943.

134. Rhodes, W. L.: Allergy and Infection of the Nose and the Paranasal Sinuses, M. Rec. **156**:224 (April) 1943.

Smith, Goodhill and Webb [135] state that in California the problem of allergy as related to pollinosis is complicated by the fact that the reactions are different in the three chief regions, namely, coastal, intermountain and desert. Also, the allergy, at first seasonal, soon tends to become perennial. It has been their experience that in most of the cases of recurring colds and sinus symptoms the trouble is due to pollen sensitivity. The varying types of reaction to patch and intracutaneous tests and the methods of administering appropriate pollen therapy are adequately described.

MISCELLANEOUS

Harper's [136] paper deals chiefly with the question of so-called "latent" or "occult" sinusitis, in which the usual symptoms and findings are meager, though the patient may suffer from a wide variety of disorders, both local and remote. In many cases of this type he has found extensive disease of the mucosa and has cultured virulent strains of streptococci. He feels that many patients who have failed to obtain relief from submucous resection and other minor surgical procedures and who still complain of frequent colds, postnasal drip, gastric disturbances, mental fatigue and vague aches and pains are the victims of a chronic pathologic process within one or more sinuses which eludes all but the most careful and persistent search. Despite negative results from diagnostic puncture and doubtful roentgenograms, it should still be possible to diagnose these conditions. He mentions edema of the mucosa of the lateral nasal wall and mucus in the deeper recesses of the nasal passages as suspicious signs and emphasizes the need for the best roentgenograms with experienced interpretation. He fails, however, to mention the use of contrast mediums or planigrams, which many have found extremely valuable in doubtful cases.

As for therapy, he is convinced that these patients need radical surgical treatment with removal of all diseased mucous membrane and suggests the Caldwell-Luc operation with transantral approach to the ethmoid cells.

Kelemen [137] reviews the literature on the relationship of vitamin deficiencies to sinus infection and suggests that a closer study of the nutritional status of patients with sinusitis might be productive of valuable information. A series of 100 consecutive adults was studied with especial reference to height and body weight. It was found that there was a high incidence of overweight, particularly in women between 30 and 60 with no especially outstanding general or endocrine factors. The author believes this to be the result of neurotic eating habits, which the patient is loath to alter, and that this overweight places a burden on the whole circulatory and respiratory apparatus which had been established for a certain reasonable height-weight relationship.

Neil [138] has seen a large number of soldiers returned from active duty with acute otitis media and sinusitis, which he believes has been caused by violent blowing of the nose with forcing of infected mucus into these cavities. He bases his contention on the absence of local evidences of acute inflammation in the nasal tissues and on the presence of acute pain about the sinus, with roentgenograms showing haziness about the periphery. He is emphatic in his condemnation of blowing the nose with nostrils compressed and suggests posterior suction of secretions by the patient as an alternative.

135. Smith, H. D.; Goodhill, V., and Webb, M. E.: Nasal Allergy, the Otolaryngologist's Problem, California & West. Med. **58**:275 (May) 1943.

136. Harper, J.: Advances in the Treatment of Chronic Nasal Sinusitis, Practitioner **149**:364 (Dec.) 1942.

137. Kelemen, G.: Sinusitis and Obesity, Laryngoscope **53**:288 (April) 1943.

138. Neil, J. H.: Acute Otitis Media and Sinusitis in the Soldier, New Zealand M. J. **42**:173 (Aug.) 1943.

# Abstracts from Current Literature

## Ear

A Hearing Aid Clinic. B. H. Senturia, S. R. Silverman and C. E. Harrison, J. Speech Disorders **8**:215 (Sept.) 1943.

Seventy-five unselected cases of deafness are reported. Of these, 19 were instances of conduction deafness, 29 of mixed deafness and 17 of perception deafness. Thirteen hearing aids approved by the Council on Physical Therapy of the American Medical Association were tested for efficiency with various types of deafness; some are better than others, depending on the type of deafness. A slight increase in hearing may result in a great increase in intelligibility due to the fact that gaps in the auditory pattern are filled. The authors believe that a period of acoustic training is desirable after the acquisition of a hearing aid.

Palmer, Wichita, Kan. [Am. J. Dis. Child.]

The Effects of Noise and Concussion on Hearing. H. B. Perlman, J. Speech Disorders **8**:289 (Sept.) 1943.

The specific acoustic and physiologic factors that relate noise and concussion to the auditory sense are analyzed. Sensitivity to high frequencies is often lost through acoustic trauma. The author reports considerable personal clinical experience and reviews the literature. The results observed during the Spanish Civil War are cited to show various effects of sudden large pulses of sound. Cerumen in the ears may rupture the ear drum. Occasionally fracture of the temporal bone occurs. Many cases of deafness due to noise or concussion are not reported; a manual laborer, for example, will not be as keenly aware of a loss in degree of hearing as a musician.

Palmer, Wichita, Kan. [Am. J. Dis. Child.]

Prevention and Treatment of Acoustic Trauma. George E. Shambaugh Jr., J. Speech Disorders **8**:369 (Dec.) 1943.

The most common type of loss of hearing observed after acoustic trauma is a decrease in sensitivity to sounds with a frequency of approximately 4,096 cycles per second, and the next most frequent type is complete loss of hearing. Temporary or permanent damage of the nerve cells in the inner ear always occurs.

Since there is no treatment for acoustic trauma, prevention is essential. The following recommendations are made: 1. Routine audiometric testing should be done on all persons, such as aviators, who are exposed to excessively loud noises. 2. Persons susceptible to acoustic trauma should be transferred to quieter surroundings. 3. Excessive noise should be controlled by the use of improved designs for engines, machinery and buildings. 4. Where noise cannot be reduced, aural protectors should be worn. The most important preventive measure is repeated routine audiometric testing.

Palmer, Wichita, Kan. [Am. J. Dis. Child.]

## Pharynx

Radium Treatment of Granular or Hypertrophied Lateral Pharyngeal Tonsillar Bands. Robert E. Fricke and Peter N. Pastore, Radiology **41**:256 (Sept.) 1943.

In chronic pharyngitis the lymph follicles covering the entire pharynx and nasopharynx are hypertrophied, and raised patches due to lymphoid cells around the duct are easily seen. This condition is the so-called granular pharyngitis. When lateral pharyngeal tonsillar bands are hypertrophied, the infection is usually termed "lateral pharyngitis." Elimination of all infected tissue in Waldeyer's ring cannot be accomplished by operative procedures alone; only the faucial or palatine tonsil can be completely removed surgically. After the operation there is a tendency, in some instances, for the lateral pharyngeal bands or the tonsillar plaques in the lateral pharyngeal walls to undergo hypertrophy. Treatment by a variety of therapeutic measures has not been satisfactory. Although granular pharyngeal tonsillar bands are occasionally unattended by symptoms, they are a potential source of acute infection and of a painful and disabling sore throat.

Small doses of radium were safely employed, using an especially designed radium applicator, with gratifying success. A metal rod is threaded at the end so that a brass and silver tube containing radon can be attached; a hinged joint has been introduced just behind the attachment. The end of the rod, with the tube containing the radon attached, is passed through the nostril under topical anesthesia. When the rod is turned, the hinged portion drops downward and lies against the hypertrophied lateral band. The hinge is constructed to lock at an angle of about 50 degrees, so that the long axis of the radon tube presses against the lateral pharyngeal wall.

The dose of radium used varied in the earlier cases from 1.5 to 4.5 gram minutes, but later it was standardized at 3 gram minutes to each lateral pharyngeal tonsillar band. Usually about 50 millicuries of radon was used; hence, one hour's application through each nostril furnished the planned dose. Twenty patients had only one treatment each with radium; 4 had two treatments each, a few months apart. Two of the 24 patients were given roentgen therapy, and 3 of them had surgical treatment in addition to the radium therapy. The authors consider it probable that the treatment will need repetition from time to time, because of the recovery of the lymphoid structures after several months.

Anspach, Chicago. [Am. J. Dis. Child.]

## Larynx

Severe Sublingual and Paratracheal Hemorrhage in Hemophilia with Recovery Following Tracheotomy. Katherine H. Baird and Meyer S. Fox, J. Pediat. **23**:90 (July) 1943.

One type of hemorrhage in hemophilia is of especial danger, that is, bleeding into the sublingual and para-

tracheal tissue, which may produce asphyxia before the loss of blood is in itself significant.

A review of the literature reveals reports of 7 cases of such bleeding. In 4 cases the symptoms were not sufficient to warrant tracheotomy and the patients lived. In 3 cases in which tracheotomy was necessary the patients died.

The case reported is that of a 4½ year old hemophilic boy in whom a massive sublingual and paratracheal hemorrhage developed during the course of an infection of the upper portion of the respiratory system. Tracheotomy became necessary and was successfully performed, with immediate relief of the respiratory distress. Favorable progress followed the use of repeated large transfusions of blood totaling 2,850 cc.

SHMIGELSKY, Chicago. [AM. J. DIS. CHILD.]

MEDIASTINAL EMPHYSEMA AND PNEUMOTHORAX FOLLOWING TRACHEOTOMY. GILBERT B. FORBES and G. W. SALMON, J. Pediat. **23**:175 (Aug.) 1943.

Whenever tracheotomy is performed on a patient who exhibits severe respiratory obstruction or labored respiratory efforts, the possibility of the development of mediastinal emphysema must be considered. Four cases in which this occurred are presented. The symptoms are cyanosis and respiratory distress, and occasionally sudden death occurs. Mediastinal emphysema is easily diagnosed by fluoroscopy with the patient in the lateral position, and the pneumothorax which may result from the emphysema, by the usual signs. Simple aspiration of the air is often sufficient to relieve the symptoms which arise from the latter condition; it rarely succeeds in alleviating the emphysema because of pocketing of the air in the loose mediastinal tissues. Various possible mechanisms responsible for the emphysema are discussed; the most likely is the sucking of air into the mediastinum along the fascial planes of the neck. Pneumothorax presumably occurs by the escape of air through a rupture in the relatively thin mediastinal pleura, aided by the decreased intrathoracic pressure resulting from inspiratory efforts against an obstructed airway.

SONTAG, Yellow Springs, Ohio. [AM. J. DIS. CHILD.]

ACUTE LARYNGOTRACHEOBRONCHITIS IN CHILDREN. JOHN A. V. DAVIES, New England J. Med. **229**:197 (July 29) 1943.

In past years acute laryngotracheobronchitis has carried a mortality of 50 to 100 per cent.

It must be differentiated from simple spasmodic croup and laryngeal diphtheria, usually by its acute onset and the rapid progress of its symptoms.

Almost 50 per cent of the patients are 2 years of age and under.

There has been a tendency to consider beta hemolytic streptococci as the only organisms involved, whereas Staphylococcus aureus, Haemophilus influenzae and pneumococci are also frequently present.

Treatment may be started with sulfathiazole or sulfadiazine or with penicillin if it is available. Inhalations of cool oxygen appear more helpful than those of steam. All preparations should be made for tracheotomy should it become necessary, and the availability of an aspirator should be assured. The intratracheal insertion of a Mosher tube may prove life saving.

GENGENBACH, Denver. [AM. J. DIS. CHILD.]

## Nose

THE PHYSIOLOGY OF DRAINAGE OF NASAL MUCUS: IV. DRAINAGE OF THE ACCESSORY SINUSES IN MAN. A. C. HILDING, Ann. Otol., Rhin. & Laryng. **53**:35 (March) 1944.

Interesting experiments are described, showing the direction of flow of mucus in the sinuses. All except the maxillary sinuses were opened in necropsy material, small drops of india ink were dropped on the mucosa and the direction of ciliary action was studied. The maxillary sinus was studied through windows. In general the ink in each sinus showed a spiral movement toward the osteum. None of the ink in the maxillary sinus was seen to pass out through the artificial opening. By means of ciliary action the sinus is drained of the normal film of mucus every fifteen minutes. When secretion is sufficiently stimulated, however, the film of mucus becomes so deep that when the vertical walls are reached, only the deepest portion of the film passes through the osteum; the rest falls back to the bottom of the cavity by gravity.

M. V. MILLER, Philadelphia.

TWO CASES OF OSTEOMYELITIS TREATED WITH PENICILLIN: CASE 1. FRONTAL; CASE 2, MAXILLARY. SAMUEL IGLAUER, Laryngoscope **54**:150 (March) 1944.

The author presents 2 cases of osteomyelitis complicating sinusitis. Both patients showed bacteremia due to infection with a hemolytic staphylococcus. The administration of sulfonamide compounds was instituted, and the involved bone was treated surgically. Only after treatment with penicillin did recovery occur.

HITSCHLER, Philadelphia.

## Miscellaneous

STUDIES ON THE CONTROL OF ACUTE INFECTIONS OF THE RESPIRATORY TRACT: III. RESULTS OF SULFADIAZINE THERAPY FROM MAY 3, 1942 TO MAY 2, 1943. MORRIS SIEGEL, Am. J. Dis. Child. **67**:365 (May) 1944.

Since 1941 Siegel has worked in the Division of Infectious Diseases of the Public Health Research Institute of the City of New York, under a grant from the Metropolitan Life Insurance Company. He now publishes the third instalment of his results. A group of "highly susceptible children" (children subject to epilepsy) at Letchworth Village were treated by sulfadiazine for acute respiratory diseases over a twelve month period. The results were similar to those obtained during the first six months previously reported. The illnesses were milder than those in the untreated children with certain exceptions, notably virus-borne diseases. These effects were attributed to bacteriostasis. They were influenced by the nature and the degree of virulence of the inducing agent. "The drug seemed to exert a stabilizing effect on the course of (these) acute infections." Siegel thinks that sulfadiazine might be of great value during outbreaks of influenza and other respiratory diseases in which drug-susceptible bacteria are implicated.

These researches seem to have been carried out with care and precision under laboratory and other controls which would prevent errors in judgment. It is somewhat disappointing, however, to see no brilliant "cures" as a sequence. One is probably becoming too expectant of such results. This may be due to the reports from

Army and other sources which are pushing penicillin in therapeusis. Some think that the sulfonamide drugs will be supplanted. It is too early to state this as fact, but, perhaps, one may be hopeful without being over-enthusiastic.

VOORHEES, New York.

USE OF CRUDE PENICILLIN IN MEDIA FOR THE ISOLATION OF HEMOPHILIS INFLUENZAE FROM LARYNGEAL CULTURES IN OBSTRUCTIVE LARYNGITIS. LILLIAN BUXBAUM and NICHOLAS F. FIEGOLI, J. Bact. **46**: 543 (Dec.) 1943.

The syndrome of laryngotracheobronchitis has been attributed to Haemophilus influenzae. The organism has been isolated frequently but often with difficulty. The authors stress the importance of identifying the causative micro-organism in this disease in order that proper treatment may be instituted. The material removed from the larynx and trachea for bacterial study has been found to contain gram-positive cocci, the overgrowths of which make it difficult to isolate H. influenzae. After the publications of Fleming concerning the antibacterial action of filtrates of Penicillium notatum it was observed that the addition of crude penicillin to blood agar plates provides a simple but excellent medium for the isolation of H. influenzae from the mixed cultures usually obtained from the larynx. The authors obtained typical growths of H. influenzae from the penicillin mediums in practically pure cultures. It was found that these cultures could be used without further transplants for serologic identification and for testing the patient's antibody. The suggestion is made that the ease of preparation of these penicillin plates with stock laboratory mediums used as a base makes them convenient in a busy diagnostic laboratory.

STOESSER, Minneapolis. [AM. J. DIS. CHILD.]

DIADOCHOKINESIS IN STUTTERERS AND NON-STUTTERERS. CHARLES R. STROTHER and LOIS SMASON KREIGMAN, J. Speech Disorders **8**:323 (Dec.) 1943.

Fifteen adult stutterers, 11 men and 4 women, were compared carefully with a control group of approximately the same distribution for sex, dextrality quotient and rhythm. The authors were unable to confirm the previous studies of Blackburn, Rotter, West and Cross; no significant differences between stutterers and non-stutterers were found in respect to rate of diadokokinetic movement of the lips, tongue, jaw or fingers.

PALMER, Wichita, Kan. [AM. J. DIS. CHILD.]

THE ETIOLOGY OF STAMMERING: THE PSYCHOPHYSIOLOGIC FACTS WHICH CONCERN THE PRODUCTION OF SPEECH SOUNDS AND OF STAMMERING. ELMER L. KENYON, J. Speech Disorders **8**:337 (Dec.) 1943.

The author reviews the psychophysiologic facts of laryngeal action and the production of sound and restates his theory that stuttering is a result of compulsory interpolation of normal adduction of the vocal cords when phonation is attempted.

PALMER, Wichita, Kan. [AM. J. DIS. CHILD.]

A PREDISPOSING CAUSE OF STUTTERING. JOHN M. FLETCHER, Quart. J. Speech **29**:480 (Dec.) 1943.

An important predisposing cause of asynergic movements, such as those observed in stuttering, is the fact that a person has only indirect control over the muscles involved in such movements, since the asynergies disappear when the remotely controlled muscles are eliminated.

PALMER, Wichita, Kan. [AM. J. DIS. CHILD.]

# News and Comment

## DIRECTORY OF MEDICAL SPECIALISTS CERTIFIED BY AMERICAN BOARDS 1945. PUBLISHED BY THE ADVISORY BOARD FOR MEDICAL SPECIALTIES

The biographic data of the first two editions of the "Directory of Medical Specialists" included only positions (internships, residencies or assistantships) held during the course of training of men up to the time of their certification by the American Boards, and positions on hospital and medical school staffs then currently held.

It is desired to extend these data in the third edition to include all formal appointments to hospitals and medical schools, with dates for which they were held, even though the appointee has now resigned, as well as records of all military service, including commissions and dates, whether in World War I, in the reserve forces in peacetime or in the present war.

Thus, a chronologically complete sketch of the entire career of a certified specialist is to be included in this third edition of the "Directory."

Membership or fellowship in national or sectional (not local) special societies and national general societies, with offices held and dates, should be reported.

Membership in recognized international medical societies may be included, but honorary or other membership in foreign medical societies should not be reported.

The certificate may refer to the second edition (1942) of the "Directory" for lists of medical societies to be included in his biographic sketch.

Families or secretaries of men absent in military service are asked to complete or correct previous listings or to prepare new forms now being mailed to physicians eligible for inclusion in the "Directory." Only persons certified by an official American Board can be included, and there is no charge for this listing.

This notice is published in response to many inquiries to assist physicians certified by the American Boards who are now engaged in correcting their previous listings or in preparing new sketches for the third edition of the "Directory," to be published early in 1945.

Communications should be addressed to the Directory of Medical Specialists, 919 North Michigan Avenue, Chicago 11.

# Society Transactions

## CHICAGO LARYNGOLOGICAL AND OTOLOGICAL SOCIETY

SAMUEL J. PEARLMAN, M.D., *President*

WALTER H. THEOBALD, M.D., *Secretary*

*Regular Monthly Meeting, Jan. 3, 1944*

### A SYMPOSIUM ON MÉNIÈRE'S SYMPTOM COMPLEX

**Otolaryngologic Point of View.** Presented by DR. JOHN R. LINDSAY.

The term "Ménière's syndrome" has been used in connection with a group of diseases with paroxysmal vertigo, tinnitus and deafness which could not be explained on the basis of inflammatory disease, tumor or trauma. Clinical and pathologic observations have more recently made it possible to distinguish several entities within this general group. The term "Ménière's disease" has recently been used to denote a clearcut clinical syndrome of recurrent attacks of vertigo, tinnitus and deafness. It is fairly well established that in the patients with this disease the pathologic condition in the inner ear is labyrinthine hydrops. The term "pseudo Ménière's disease" has been used to denote attacks of vertigo without auditory symptoms and without other neurologic signs. This clinical picture is comparatively common and serves to complicate the diagnostic problem. The questions the otologist must answer in any case of dizziness are:

1. Is the vertigo of the vestibular type?

2. Is the basic disturbance located in the peripheral vestibular apparatus (including the eighth nerve) or is it central?

3. What evidence can be elicited that may help localize a lesion of the central nervous system?

Dizziness of nonvestibular origin can usually be differentiated on the basis of a careful history. The complete syndrome of tinnitus, deafness and vertigo indicate a peripheral lesion. In cases of vertigo without auditory symptoms it is difficult to localize the site of the disturbance. Postural vertigo is extremely common in this group. Special examination for postural nystagmus may give information that would help differentiate between peripheral and central disease. Postural nystagmus, according to Nylen, is of two general types: Type 1: The nystagmus changes direction in different positions or while the patient is in the same position. Type 2: The direction is constant.

Clinical observations indicate that type 1 occurs only with lesions of the central nervous system. Type 2 may occur with either peripheral or central lesions. Positional nystamus associated with a purely peripheral lesion is not common. Three cases are presented to illustrate (1) early Ménière's disease, (2) toxic neuritis or labyrinthitis and (3) vertigo in connection with catarrhal otitis media. In all these instances there was positional nystagmus type 2. Four other cases in which postural vertigo was observed are described, which fall into the group of cases sometimes classified as instances of pseudo Ménière's disease. One was a case of hypertension and arteriosclerosis; in the remaining 3 the patients were in a "hypotensive stage" characterized by very low and variable blood pressure. In the latter 4 cases the postural nystagmus was always type 1, indicating that the vertigo was probably of central origin and that true Ménière's disease could be ruled out. Such attacks are usually infrequent and sometimes not repeated.

In cases of positional nystagmus a labyrinthine fistula must always be ruled out.

Conditions which have been commonly classed as Ménière's syndrome include: vertigo due (1) to catarrhal changes in the middle ear, which is rare, (2) allergy, also infrequent, (3) hemorrhage and thrombosis, distinguished by the extensive permanent damage to function, the gradual recovery from the vertigo and the absence of recurrence; (4) toxic neuritis or labyrinthitis, also diagnosed by the characteristics of the attack; (5) Ménière's disease (labyrinthine hydrops). The latter may start with auditory symptoms, such as tinnitus or deafness or as a simple attack of vertigo, but cannot be diagnosed until the complete syndrome is present. The auditory threshold varies widely in different stages of an attack. Bone conduction is depressed along with air conduction. Postmortem examination has demonstrated labyrinthine hydrops as the basic pathologic entity. The etiologic factors are still indefinite.

Medical and neurosurgical treatment are not discussed in this presentation. A small percentage of cases require surgical intervention to prevent the vertigo. In these a surgical procedure that will be universally satisfactory must preserve the hearing. Up to the present time the only procedures on the labyrinth that have met these requirements are Portmann's operation and a modification of the fenestration operation. Neither has as yet been universally satisfactory.

**Neurosurgical Point of View.** Presented by DR. ERIC OLDBERG.

In 1861 Ménière first described the syndrome which bears his name, that of tinnitus, deafness and paroxysmal attacks of vertigo. In 1874 Charcot hypothecated that since these patients tended to recover when they became totally deaf, division of the acoustic nerve might be of therapeutic benefit. This was again suggested in 1894 by Sir Charles Ballance. The first recorded division of the eighth nerve was done in 1905 by Krause, who, however, performed the operation for tinnitus rather than for Ménière's syndrome. In 1908 both Ballance in England and Frazier in the United States cut the eighth nerve for Ménière's disease. In 1928 Dandy suggested that the eighth nerve could be subtotally sectioned, the auditory fibers being spared and only the vestibular fibers divided. The first man to put this suggestion into practice was McKenzie in Toronto in 1931, and in 1933 Dandy began differential sections—now the accepted surgical procedure for the condition. In 1932 an alternative operation was pro-

posed by Putnam, in which the middle fossa and the petrous ridge were exposed and the vestibular ganglion electrically coagulated. The latter operation, however, has not been greatly utilized.

The syndrome is characteristically present in middle and later life and is more common in males than in females; it occurs more often on the left than on the right side. Before entertaining ideas of surgical intervention, one should differentiate the given condition from labyrinthitis and from tumor of the cerebellopontile angle. If, in spite of adequate medical therapy, including a salt-free diet and treatment with histamine and nicotinic acid, the attacks are so violent and so frequent over such a period that the patient is seriously disabled for gainful occupation, then the idea of surgical intervention must be entertained, unless total deafness is rapidly intervening and offers some hope of spontaneous cure. Differential section of a half or slightly more than a half of the eighth nerve is the operation of choice, and this can usually be done so as to section a minimum of cochlear fibers and a maximum of vestibular fibers. Whereas the operation should carry a very low mortality risk, it nevertheless is a major procedure, since the cerebellopontile angle must be exposed. In view of the comparative frequency of vascular anomaly in this area, the morbidity risk, with special reference to the facial nerve, is higher than the mortality risk. The operation may usually be expected to stop the attacks of paroxysmal vertigo. However, it does not stop the progress of deafness, and in a fairly large percentage of cases it does not stop the tinnitus. There are usually no disabling postoperative complications, such as diplopia or positional vertigo, in the average case, although these sometimes occur, especially when a bilateral operation has been performed.

In conclusion, and in order to indicate the wide variety in philosophy of treatment, it may be stated that at approximately the same date (1940-1941) 20 such operations had been performed in one large clinic and 401 in another clinic of considerably less size.

**Medical Point of View.** Presented by DR. BAYARD P. HORTON, Rochester, Minn.

Ménière's symptom complex is characterized by recurrent attacks of sudden severe vertigo, nausea, vomiting, tinnitus and deafness of unknown cause. It constitutes a definite clinical syndrome. Numerous forms of therapy have been suggested since the syndrome was first described by Ménière in 1861; however, the perfect treatment has not yet been announced.

My interest in the problem began with the introduction of histamine therapy. Shelden and I stated in our first communication regarding histamine therapy that "our purpose in presenting this form of therapy is to make available to the medical profession a quick and ready method for controlling the acute symptoms of Ménière's disease" (Shelden, C. H., and Horton, B. T.: Treatment of Ménière's Disease with Histamine Administered Intravenously, Proc. Staff Meet. Mayo Clinic. **15**:17-21 [Jan. 10] 1940). At that time we had in mind primarily the vertigo of Ménière's disease. Since this original publication a large number of patients having Ménière's symptom complex have been treated at the Mayo Clinic (Horton, B. T.: The Use of Histamine in Ménière's Disease, Surg., Gynec. & Obst. **72**:417-420 [Feb. 15] 1941). I still consider that intravenous histamine therapy is the best method for controlling the acute symptoms of this disease. (A detailed report of the investigation of these cases will be published later after this further experience.) I realize, however, that it is extremely difficult to evaluate any type of treatment for Ménière's syndrome because many patients make spontaneous recoveries from this disease.

Vertigo is the essential feature in Ménière's symptom complex and represents a local process involving the labyrinth. The presence of tinnitus and varying degrees of deafness probably indicates that the process also involves the cochlea. The process most likely responsible for Ménière's syndrome is local alteration in the permeability of the capillary wall with secondary local edema.

During acute attacks the majority of patients have objective vertigo, and it is interesting to note that a higher percentage of patients who have this type of vertigo derive benefit from treatment with histamine than of patients who have subjective vertigo. Why this is true is not clear at present.

Although vertigo is the essential feature in Ménière's disease, tinnitus is also an annoying complaint and a difficult one to treat. Tinnitus appeared simultaneously with the onset of vertigo in 45 per cent of the cases of Ménière's disease studied. It preceded the vertigo in approximately 28 per cent and followed vertigo in 21 per cent. In the remaining 6 per cent the exact time of onset of tinnitus could not be determined. The onset of some degree of deafness occurred simultaneously with the onset of vertigo in 48 per cent of cases. It preceded vertigo in 38 per cent and followed vertigo in approximately 14 per cent.

If patients are promptly given histamine intravenously during the initial acute attack, it seems to be possible to prevent deafness in a large percentage of cases. Patients so treated in and around Rochester have had little or no loss of hearing.

Dr. B. E. Hempstead and I have recently observed a patient aged 46. Complete loss of hearing in her right ear began with the initial attack of vertigo. Intravenous histamine therapy was started approximately seventy-two hours after onset of the attack. Following sixteen daily intravenous injections of histamine diphosphate (in twelve the drug was given in 0.8 per cent solution of potassium chloride and in the remaining four in 0.9 per cent solution of sodium chloride), not only did she obtain complete relief of vertigo but the hearing in the right ear improved to within almost normal limits. The hearing in the left ear was entirely normal and remained so.

In my opinion, the most important point to keep in mind when confronted with a patient who has acute symptoms is the need for prompt institution of treatment in an attempt to prevent loss of hearing. As stated before, I believe loss of hearing can best be prevented and the acute attack aborted by intravenous administration of histamine.

The second patient was a physician's wife, aged 38. When she was observed first, she complained of nausea, vomiting, tinnitus, and marked loss of hearing in the left ear. She received histamine diphosphate intravenously on Nov. 23, 24 and 27, 1939. At the completion of the first intravenous injection she was able to hear moderate tones in the left ear and the tinnitus had lessened approximately 75 per cent. Since she was the second patient treated in this manner, she was allowed to go home, and we awaited future developments. She was seen again Feb. 23, 1940, with an acute attack of vertigo, tinnitus in the left ear, nausea,

vomiting and a sensation of pressure in the head. Intravenous histamine therapy was started immediately; the nausea disappeared in approximately eight minutes, the bed stopped "whirling" within fifteen minutes and the tinnitus disappeared at the end of an hour. She was then able to get up and walk without assistance. Her husband has continued to give her daily subcutaneous injections of histamine diphosphate (approximately 0.05 to 0.067 mg. of histamine base) and she has remained free from attacks up to the present.

Many patients with Ménière's symptom complex have a horror of these attacks. The fear of vertigo seems to incapacitate as many patients as does vertigo itself. Many physicians do not seem to appreciate this fact.

It has not been possible to distinguish between the so-called "histamine-sensitive" and the "histamine-insensitive" types of Ménière's symptom complex as suggested by Atkinson of New York. The problem is not that simple. Any one interested in the subject of cutaneous tests for sensitivity to histamine will do well to read Browne's article, which is an abridgment of a thesis for which the work was done in my laboratory (Browne, H. C.: Cutaneous Reactions as an Index to Desensitization to Histamine, J. Allergy **14**:19-48 [Nov.] 1942).

Misconceptions have arisen in the minds of members of the medical profession regarding intravenous histamine therapy. The method of giving 2.75 mg. of histamine diphosphate intravenously in a 1:250,000 dilution of isotonic solution of sodium chloride U. S. P. is a simple procedure, and at the Mayo Clinic a large number of such injections have been given to patients with Ménière's symptom complex without any untoward effects. Furthermore, the majority of these patients have been ambulatory, as hospitalization was not necessary.

One of my associates, Dr. Peters, suggested several months ago that histamine diphosphate (2.75 mg. of histamine diphosphate) be given in 0.8 per cent solution of potassium chloride instead of 0.9 per cent solution of sodium chloride. This procedure has been carried out in many instances. Whether there is any advantage in isotonic solution of potassium chloride over isotonic solution of sodium chloride has not been determined as yet.

### DISCUSSION

DR. ALFRED LEWY: The terms "Ménière's syndrome," "Ménière's disease" and "pseudo Ménière's disease" are, I believe, confusing. There is no clinical correlation, as proved by remedial measures, to indicate that physicians know what they are dealing with in many cases. There is no doubt that in many instances the disease is due to ectasia of the membranous labyrinth, but until the diagnosis is proved correct by the response to remedial measures in a considerable number of cases, I do not think one should give the syndrome a definite name. I believe one should observe the patient from the standpoint of the vertigo, and then rule out one by one the various things that may produce vertigo. I also object to the term "toxic labyrinthitis." Some of the patients I have seen whose condition had been diagnosed as toxic labyrinthitis had those symptoms as the result of encephalitis.

Mention has been made also of the Bárány test. I have recently observed a patient, a young man about to be inducted into the Army, who had been examined by a neurosurgeon, who diagnosed a functional disturbance. When I saw the patient I found definite postural nystagmus and perverted caloric nystagmus. I returned him to the neurosurgeon and said I believed he had an organic lesion in the posterior fossa. He was again hospitalized, although the neurosurgeon thought it was a psychogenic condition; eventually he found evidence of cerebellar tumor, which was removed. If one appreciates the condition from the standpoint of vertigo, I think one is less apt to go astray in the matter of treatment for this so-called Ménière's syndrome.

DR. LEONARD CARDON: As an internist, I should like to ask a question. Injections of histamine phosphate are used to produce experimental peptic ulcers in animals. I should like to know whether there is any clinical evidence that this danger is present in patients being treated for Ménière's or other syndromes by repeated injections of histamine phosphate.

DR. JOHN R. LINDSAY: I enjoyed Dr. Oldberg's discussion of the neurosurgical aspect of this problem, and also Dr. Horton's remarks, especially his statement to the effect that they had proposed histamine treatment only to relieve or abort an acute attack. In my experience with histamine this has been the only desirable result obtained. Unfortunately physicians seldom see the patient in the acute stage of an attack and therefore have not often been able to evaluate the effects of histamine in that respect; but my colleagues and I have not been able to prevent attacks.

One reason why I pointed out the wide fluctuations in the hearing was that I might indicate why one cannot evaluate therapeutic effects on the basis of an alteration in the threshold of hearing. I have never seen a patient with a 40 or 50 decibel loss regain normal hearing. If a patient has lost his hearing completely and then recovers it entirely, there is a question as to the diagnosis of Ménière's disease.

With regard to Dr. Lewy's statement about toxic neuritis versus toxic labyrinthitis, it can be said that no one knows the exact pathologic process or its limitations. One reason why I showed cases of postural vertigo without auditory abnormalities was because it is my impression from the literature that many cases are improperly classed as instances of Ménière's disease since the vertigo may be of central origin. Some of the patients never have a recurrence; others may have a few, but it is difficult to see any justification for operation. I think it is of considerable help in diagnosis with respect to this particular group of patients to make a routine investigation as to whether they have postural nystagmus.

DR. B. T. HORTON: My associates and I feel that the intravenous administration of histamine (2.75 mg. of histamine diphosphate in 250 cc. of isotonic solution of sodium chloride, administered at the rate of 30 to 90 minims [2 to 5.5 cc.] per minute, depending on the tolerance of the patient) is a safe and efficient form of therapy. It will abort the acute symptoms of this disease in the majority of instances. It is not necessary except in rare instances to hospitalize patients for this procedure.

Since we began this type of experimental therapy in 1939 we have given approximately 14,700 such injections to patients of various types, including those with Ménière's symptom complex and multiple sclerosis, without any ill effects except in 1 patient, a man aged 20. He had multiple sclerosis, and in him an acute gastric ulcer developed after 13 injections. A roentgenogram of the stomach showed an ulcer on the

lesser curvature, which healed completely within twelve days after intravenous histamine therapy had been discontinued.

In our routine procedure, in which patients receive daily intravenous injections, as in our experimental work with reference to multiple sclerosis, it is important to have the patient eat a full meal immediately before administration of the drug. This particular patient had failed to do so. When histamine is administered, it produces a maximal rise in gastric acidity; hence it is important to have food in the stomach to absorb the excess gastric acids. It is interesting to note that during our experimental work we have given more than 328 such injections to a patient having multiple sclerosis without producing any measurable ill effects.

Dr. Lindsay has discussed the pathology of Ménière's symptom complex, and I do not feel that I can add anything to his discussion. As I have previously indicated, the factor most likely responsible for Ménière's symptom complex is local alteration in the permeability of the capillary wall with secondary local edema of the labyrinth.

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# CONTENTS


PAGE

Development of the Organ of Corti in Relation to the Inception of Hearing. O. Larsell, Ph.D., Portland, Ore.; Edward McCrady, Jr., Ph.D., Sewanee, Tenn., and Lieutenant John F. Larsell, Medical Corps, Army of the United States ..... 233

Indications, Procedures and Results in the Surgical Management of Mastoiditis: A Review of Thirty-Three Cases. Darrell G. Voorhees, M.D., New York ..... 249

Bilateral Acoustic Neuritis: A Review of the Literature and a Report of a Case. Lieutenant Colonel M. R. Johnson, Medical Corps, Army of the United States ..... 261

Reduced Atmospheric Pressure as a Form of Treatment for Paranasal Sinusitis. D. B. Butler, B.M., M.S.; G. J. Greenwood, M.D., D.D.S., and A. C. Ivy, M.D., Ph.D., Chicago ..... 266

Total Laryngectomy: Simplified Technics with the Use of a Special Clamp Which Makes Possible the Removal of the Larynx and Preepiglottic Space Without Opening the Pharynx. Edmundo Vasconcelos and Plinio de Mattos Barretto, São Paulo, Brazil ... 275

Physical Characteristics of Some Bone Oscillators Used with Commercially Available Audiometers. Frederick M. Grossman, M.D., and Charles T. Molloy, M.S., New York ..... 282

Fissural Cysts. Harry C. Rosenberger, M.D., Cleveland ..... 288

Neurinoma of the Facial Nerve. Robert M. Bogdasarian, M.D., Binghamton, N. Y. ..... 291

Case Reports:

Removal of a Frontal Osteoma and Correction of the Defect with a Tantalum Implant. Captain John J. Conley, Medical Corps, Army of the United States ..... 295

Thrombosis of the Cavernous Sinus. William B. Barry, M.D., M.Sc. (Med.), Kansas City, Kan. ..... 299

Progress in Otolaryngology. Summaries of the Bibliographic Material Available in the Field of Otolaryngology for 1943:

The Paranasal Sinuses. Samuel Salinger, M.D., Chicago ..... 301

Abstracts from Current Literature ..... 326

News and Comment ..... 328

Society Transactions:

Chicago Laryngological and Otological Society ..... 329

Directory of Otolaryngologic Societies ..... 332